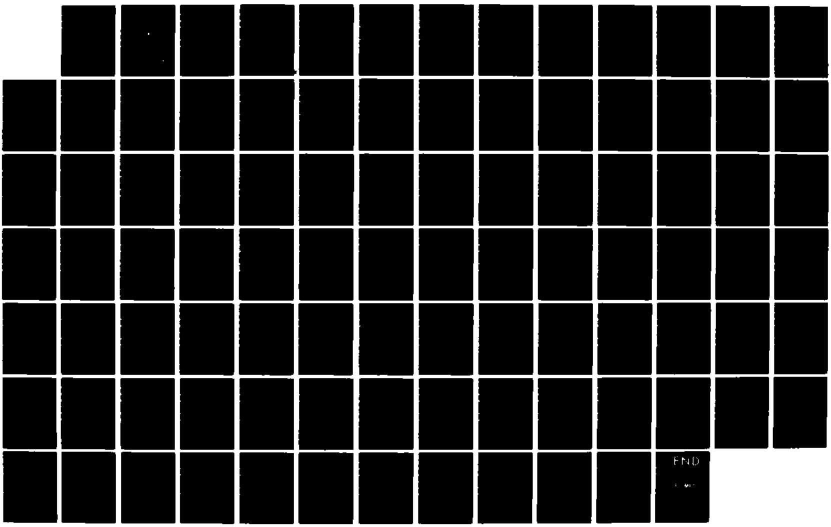
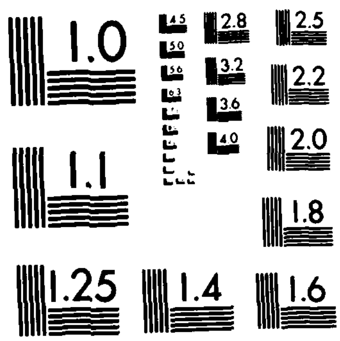
AD-A154 291 AN APPLICATION OF AMORE (ANALYSIS OF MILITARY ORGANIZATIONAL EFFECTIVENES..(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA P K SUSALLA DEC 84 1/1

UNCLASSIFIED F/G 5/9 NL





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THESIS

AN APPLICATION OF AMORE (ANALYSIS OF MILITARY ORGANIZATIONAL EFFECTIVENESS) TO THE CHARLES F. ADAMS CLASS GUIDED MISSILE DESTROYER

by

Paul K. Susalla

December 1984

Thesis Advisor George W. Thomas

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO. AD-A154 791

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle) An Application of AMORE (Analysis of Military Organizational Effectiveness) to the Charles F. Adams Class Guided Missile Destroyer

5. TYPE OF REPORT & PERIOD COVERED
Masters Thesis
December 1984

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Paul K. Susalla

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Postgraduate School
Monterey, CA 93943

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
Naval Postgraduate School
Monterey, CA 93943

12. REPORT DATE
DECEMBER 1984

13. NUMBER OF PAGES
92

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Approved for Public Release, Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
AMORE
Manpower Modeling
Cross Training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
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of personnel. AMORE is particularly useful for assessing potential benefits from cross-training.

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An Application of AMORE (Analysis of Military ORganizational Effectiveness) to the Charles F. Adams Class Guided Missile Destroyer

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MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The purpose of this thesis is to apply the U.S. Army AMORE (Analysis of Military ORganizational Effectiveness) Model to the Charles F. Adams Class Guided Missile Destroyer. This model was used to analyze the inport and underway manpower requirements by simulating personnel manning under different scenarioes. The model identified key personnel for meeting mission requirements under conditions that may lead to loss of personnel. AMORE is particularly useful for assessing potential benefits from cross-training.

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I. INTRODUCTION

Almost all organizations have personnel and materiel that are more important than others in accomplishing the organizational goal or mission. These important assets, personnel or materiel, could be referred to as essential to an organization's survival.

What is the value of the essential assets to an organization or unit? What is the cost of a lost asset which is considered essential? Can the unit recover from such a loss, and if so, how long will it take? When a unit recovers, how effective is it compared to its effectiveness before the loss? If increased sophistication causes increased specialization, how much more vulnerable is a unit after an essential loss? Could increased generalization reduce vulnerability of a highly specialized unit without decreasing its effectiveness gained by sophistication?

"Historically, the measures of unit combat effectiveness which have been used in combat models, simulations, and war games have been based almost exclusively on attrition counts." [Ref. 1: p.32] What does attrition mean in regard to the readiness or effectiveness of a combat unit? If a unit has suffered 15% casualties, is that unit now 85% effective? In the past, the analyst or military officer has used attrition counts as a general guide or indicator of unit capability. The problem is that simple attrition counting leaves interpretation of remaining unit effectiveness to the analyst.

Attrition for a military unit can be broken down into personnel attrition and materiel attrition. Different mixes of loss or attrition of personnel and materiel can mean different things for different types of units.

A 10% loss of personnel affects a unit's capability differently depending on the makeup of that loss. Some units are more dependent on individuals with command and control skills (decision makers); others are more dependent on those with operator skills or maintenance skills.

As with personnel, materiel has different implications for different types of units. Some units are more materiel dependent than others. Complexity, time and cost to repair, and the amount of diminished capability to materiel must be taken into account when attrition or partial loss of equipment has occurred.

Personnel attrition and materiel loss are often listed separately in combat models, simulations, and war games. But what, if any, is the relationship between the two? With a loss of a part of an asset, be it personnel or materiel, an organization usually has remaining assets that can substitute for the loss. Both personnel and materiel are important to an organization and are often interdependent.

The Analysis of Military ORganizational Effectiveness (AMORE) model (or method) was developed for the U.S. Army in 1976 to analyze the effects of personnel and/or materiel degradation on a unit. The methodology recognizes that a unit's effectiveness is not fixed in time, that a unit has the ability to reorganize or reconstitute its remaining resources, and that time itself is a resource. [Ref. 1: p. 32]

The purpose of AMORE is to assess a military unit's capability as a function of time after suffering some losses of assets. Through the AMORE methodology, personnel and materiel degradation are simulated in a computer model. Then a military organization's ability to reorganize quickly to overcome certain critical shortages is incorporated into this model.

Reconstruction is accomplished through the use of a transportation algorithm which uses the strength (initial quantity of assets) as supply, unit requirements as demand and a substitution matrix as the cost of the transfer. The longer the time for transfer of a remaining asset for an attrited asset, the higher the cost.

The AMORE methodology can be used to design personnel and materiel requirements for new units. It can also be used to assess current units to determine if there are additional requirements or excess resources. Or it can be used to assess a unit's capability to handle new mission requirements with assets currently alloted in order to show where additional personnel or materiel might be needed. AMORE may also be used to judge the capabilities of potential adversary units.

Besides being a tool for the planning of personnel and materiel, the AMORE process can be a training tool as well. An AMORE simulation can show where current weak points exist in organizations so that prioritized training can be conducted for a unit to reach required levels of capability quickly.

A. THE AMORE APPROACH

AMORE is a model used to simulate any organizational mission where loss of personnel and material can be expected. Through a computer simulation, many iterations of multiple missions for a single unit can be conducted taking into account different probabilities of unit asset loss. After degradation to the unit takes place, AMORE analyzes personnel, materiel, and the total unit while reconstruction of the unit is taking place using a transfer matrix.

The computer model requires the input of a great deal of information. Input parameters may be altered easily in order to test multiple "what if" questions. The required inputs are as follows:

1. Time increments and number of iterations.
2. Mission of the unit
3. Initial quantities of assets
4. Mission essential teams (MET)
5. Probabilities of degradation
6. Transfer matrixes of assets

Through the AMORE model, the computer simulation will calculate the capability of a unit at time intervals desired. Capability will be expressed as a percentage of mission essential teams reconstructed for personnel, materiel and combination of the minimum average of both. The output of the AMORE simulation will depend on the initial number of personnel and materiel assigned, the probability of degradation, the total number of mission essential teams input and the transferability of assets for the unit. The inputs are explained below.

1. <u>Time Increments and Iterations</u>

The time increments are the sections of time at which the user desires a snapshot of the percentage of reconstruction of personnel, materiel, and a combination minimum of mission essential teams which were rebuilt. The iterations are the number of simulations the user desires the computer to run without any change to any inputs. The minimum is an average of all iterations (combining both personnel and materiel) at a time increment and represents a total units' ability. U.S. Army use of AMORE has shown that 25 to 50 iterations provide the best average results regardless of the type of unit. Less than 25 iterations may provide average results that are too pessimistic or optimistic.

2. Mission

The unit mission is not input in the literal sense, but is of primary importance to the analyst because the mission determines the requirements for essential teams. Though the mission is a heading input for the AMORE simulation, it has no direct effect on the simulation.

3. Initial Quantities

Initial quantities are simply the amounts of assets, personnel and materiel, that are available for the unit.

4. Mission Essential Teams (MET)

With a mission defined, a unit is then broken down into the functions needed to accomplish the mission. The personnel and materiel used to accomplish these functions are built into teams and are called mission essential teams (MET). The minimum requirement of assets for mission accomplishment, both personnel and materiel, are assigned to these teams. These teams are cumulative and represent a reconstruction of a unit's capability to accomplish a mission.

Each mission essential team may be an equal or nearly equal contributor to the entire unit. Such independent teams are similar in capability and can function with the loss of other mission essential teams around them. However, if a more essential team is degraded, immediate reconstruction is required. Independent team structure usually considers each team as an equal or nearly equal contributor.

Interdependent mission essential team structure is also possible. The contribution of the teams to the unit are not equal. In an interdependent unit the order of mission essential team construction may be critical, but less essential teams may have a higher contribution to unit capability.

An example of independent Mission Essential Team construction is a U.S. Army tank company. Each mission essential team represents a tank. Thus each team could have repetitive assets that would represent equal or nearly equal contributions to unit capability.

In this tank example, the personnel mission essential team one consists of four personnel (a tank commander, a gunner, a loader, and a driver), and a materiel mission essential team one consists of the tank. The mission essential team two would include the same types of assets as team one but the tank commander would have the skills and capability to function as a tank platoon sergeant so as to be able to coordinate the use of two tanks as a more effective fighting unit. Team three would be identical to team one. At this point the cumulative team sequence of the unit would be three tanks and 12 personnel.

The construction of mission essential teams would continue in this way with increased command and control added at certain stages to better handle the company of tanks. Teams would also be included for the unit that provide maintenance, logistics, and administration in order to increase sustainability of the unit. An example of a possible entire tank company mission essential team buildup is located in appendix A.

With AMORE it is important to note that the first mission essential team is always the first team reconstructed if need be. For the tank example it makes little sense to have a team two with a tank leader without another tank to lead. Remaining asset substitution occurs after any degradation and always starts with the first mission essential team building up as far as possible for the total unit.

Mission essential teams of personnel and materiel are both listed individually for separate analysis. The computer will later join the two for total unit analysis.

For a U.S. Navy ship, the makeup of mission essential teams is often more interdependent. A ship cannot usually be looked at as a number of independent groups such as tanks. For Navy application, the first team must start from some basic capability such as the ability to move and generate power. Team one could be the ability for a ship to move on one engine and provide electricity. The team one for personnel and materiel would consist of the assets required to accomplish basic ship mobility.

Mission Essential Team one would provide the foundation for further team construction. The second team could be made up of the men and materiel needed to fight with one weapon system such as one gun. The third team could be another weapon system such as a missile system. The fourth team could build the capability of the ship more by providing the personnel and materiel for another engine thereby increasing mobility. Team construction could include all aspects of engineering, weapons and detection, logistics and administration for multiple missions.

The dependent nature of Navy mission essential team construction is a reliance on mobility type (engineering) teams to provide basic power for the other teams. Specialization of personnel and materiel as well as volume and weight restrictions require this dependent nature.

5. Probability of Degradation

With the mission essential teams established utilizing available assets of personnel and materiel for mission accomplishment, the next step in the AMORE methodology is establishing the probability of degradation. The probability of degradation is established for each individual asset both personnel and materiel. According to the AMORE user's manual, the effect of the degrading mechanism (assigning the probability of degradation) on a unit with the assumed mission (mission stated) and posture (the mission essential teams established earlier) must be evaluated to determine the personnel and materiel degradation probabilities. These effects may vary between personnel skill groups and equipment types due to inherent differences in personnel postures and equipment vulnerabilities. A variety of methodologies may be used for the evaluation. The universally accepted Joint Munitions Effectiveness Manual (JMEM) methodologies are commonly used to establish probabilities of degradation from simulated attacks. [Ref. 2: pp.1-6]

Another commonly used practice is to analyze parametrically degradation of a unit. This is simply analyzing the unit with many different degradation probabilities. Different levels of degradation can produce different effects to a unit. The effects of degradation to a unit is more critical when a unit is unable to reconstruct back to 100%.

6. Transferability of Assets

The next step of the AMORE process is to set up the transfer matrices of unit assets. Separate transferability matrices are made for personnel and materiel functions.

A transfer matrix represents the unit commander's flexibility to reconstruct the unit after degradation. This flexibility of the commander is due to the ability of various personnel and items of equipment to function in positions other than their designated position. The times of transfers consist of the time it takes an asset to get into position to take over a function as well as the time needed for the substituting asset to become familiar with his new function in the newly reconstructed team. For instance, in the earlier example of the tank company, a transfer of a headquarters team First Sergeant (team 16 of appendix A) should he be used to fill the position of a team four Platoon Leader, the total time of transfer should include the time it takes the First Sergeant to get to the tank of team four plus the time to refamiliarize himself with the current situation of the team.

The times of transfer can often vary for individuals due to skill or experience levels of the personnel doing the substituting. The times may also vary due to unit training and the time since the last practice of the skill that a certain individual may be required to fill.

The same type of transferability matrix exists for materiel as well. A recovery or maintenance team may be able to transfer or repair materiel that is damaged and thereby build up the materiel teams.

The interdependency of the personnel and materiel is accounted for in the AMORE process. A tank out of commission without personnel attrition is still a personnel team not available unless it can transfer to other materiel that is available or unless the materiel can be substituted for or repaired. All of this interaction of materiel and personnel has time delays associated with transfers.

B. U.S. NAVY APPLICATION

This thesis deals with the Charles Adams Class Guided Missile Destroyer, (DDG-2 through DDG-24). This ship is a multi-mission destroyer containing a capability in all four of the major missions of a surface vessel. These missions include Anti-Air Warfare (AAW), Anti-Surface Warfare (ASUW), Anti-Submarine Warfare (ASW), and Naval Gunfire Support (NGFS) of Marine or Army personnel ashore. A breakdown of the ship's weapons, size, and complement is included in figure 1.1 from Jane's Fighting Ships 1983. This ship type was selected because of its sophistication and multi-mission role and because the author served on a ship of this class for four and one half years in the Engineering and Operations Departments.

Chapter two of this thesis will demonstrate the inputs required for the AMORE simulation run. The demonstration will take the form of a base case of an Adams Class Destroyer inport in an auxiliary steaming status. The personnel analysis will be of a typical duty section for this class of ship in this situation. The second section of chapter two will demonstrate the outputs of AMORE. Chapter three will continue with the inport overseas base case, but will demonstrate the effects of alternative decisions that could be made for the unit.

C. ISSUES TO BE ANALYZED

This analysis will focus on the personnel analysis of the Adams Class Guided Missile Destroyer. Though AMORE can integrate both personnel and materiel, a complete analysis of materiel will not be conducted. Materiel analysis will be included, but at a simple level.

Some of the issues to be analyzed are as follows. What kind of personnel manning mix is important for the Adams Class Destroyer in an inport readiness status? What functions are most important for an emergency sortie with only duty section personnel onboard? For an emergency scenario, how can a unit become more capable when degradation is probable but the positions that will be degraded are unknown?

The AMORE methodology considers the minimum functions which are required for a given mission. Then, with initial assets degraded, AMORE will demonstrate where weak choke

Displacement, Tons:	3,370 standard; 4,500 full load
Dimensions, feet:	437 x 47 x 20
Engineering:	2 geared steam turbines, 70,000 shp, 2 shafts, steam provided by 4 boilers at 1200 psi
Speed:	30 knots
Complement:	354 (24 officers, 330 enlisted)
Missiles:	Harpoon, surface-to-surface; Tarter, surface-to-air; Asroc, surface-to-subsurface. No matter the launcher can load, direct, and fire about six missiles per minute.Approx. 40 missile magazine.
Guns:	2 five inch 54 cal
Anti-Submarine Weapons:	2 triple torpedo tubes, as well as Asroc mentioned above.
Design:	These ships were built to an improved "Forrest Sherman" class design with aluminum superstructures and a high level of habitability including air conditioning in all living spaces.
Modernization:	Beginning in FY 1980 it was planned to give certain ships of this class a mid-life modernization, officially known as "DDG upgrade".
Radar:	3D search; SPS 39 or SPS 52; 2D air search SPS 40 or SPS 29; surface search SPS 10, fire control 2 SPG 51C/D, SPG 52A.
Rockets:	Mk 36 Super RBOC chaffroc
Sonar:	SQS 23 or SQQ 23, T-Mk 6 Fanfare torpedo decoy system.

(Source: Jane's Fighting Ships 1983-84)

Figure 1.1 Adams Class Destroyer.

points could be eliminated with specific cross-training or modifications to unit design.

The purpose of this application is to identify specifically the personnel functions that would be most advantageous for cross-training. An emphasis on general training will decrease the time it takes for substituting from one job or task to another as well as increase the number of jobs that each person can substitute for. This training can be shore-established and be conducted in boot camp as well as in individual unit training on each ship.

An IBM 3033 Mainframe Computer was used to run the AMORE Model shown here. Computer software also exists for Apple II desk top personal computers. Microcomputer technology gives each individual unit commander or officer in charge of a unit duty section the ability to analyze the unit or section capability.

II. REVIEW AND BASE CASE

In this chapter the Analysis of the Military Organization Effectiveness model inputs and outputs will be presented. An inport duty section base case will be introduced for the model. This base case will continue to be used in chapter three to analyze different inport manning strategies and duty section shipboard training policies.

A. AMORE INPUTS

1. Unit Mission

The AMORE methodology requires identification of the functions which are needed to accomplish the unit's mission. The base case mission is for an inport auxiliary steaming duty section to get the ship underway from a pier. This mission is one of the primary requirements of any U.S. Navy inport duty section when their ship is overseas or in a readiness status in homeport. For this example, a worst-case scenario will be assumed. The time is after normal work hours with a maximum liberty policy; both the Commanding Officer and Executive Officer are ashore. It is dark and the fueling pier the ship is moored to catches fire. The ship must get underway quickly.

2. Initial Personnel Strengths

The initial strengths of personnel for the base case are derived from the Ships Manning Document (SMD) of an Adams Class Destroyer (in this case, USS Tattnall DDG-19). A standard four section watchbill was derived from this SMD.

From a discussion with experienced Surface Warfare Officers, forty-one positions have been identified which are

TABLE I

INITIAL STRENGTH OF DUTY SECTION PERSONNEL

PERSONNEL DATA TASK	NAME	INITIAL STRENGTH
1	OOD	1
2	JOOD	2
3	NAVPLOT1	1
4	NAVPLOT2	1
5	STB BRG	1
6	PORT BRG	1
7	BMOW	2
8	HELM	1
9	LEE HELM	2
10	BRIDGE STAT BOARD	2
11	CIC SUPERVISOR	1
12	CIC RADAR NAV PLOT	1
13	SPS 10 RADAR NAV	1
14	RADAR SURFACE SEARCH	1
15	NC2/DRT PLOT	1
16	1JV BRIDGE PHONE	1
17	JA/JL BRIDGE PHONE	1
18	1JV FORECASTLE	1
19	1 JV FANTAIL	1
20	LINE 1 NON TECH PERS	7
21	LINE 2 NON TECH PERS	7
22	LINE 3 TECH PERS	6
23	LINE 4 NON TECH PERS	7
24	LINE 5 NON TECH PERS	7
25	LINE 6 TECH PERS	6
26	1ST LT FORECASTLE	1
27	OIC/CPO AFT LINES FANTAIL	1
28	RADIO SUPERVISOR	1
29	RADIO ASSISTANT	2
30	EOOW	1
31	BTOW	3
32	UPPER LEVELMAN	3
33	BURNERMAN	4
34	FIREROOM MESSENGER	4
35	MMOW	3
36	LOWER LEVELMAN	3
37	THROTTLE	4
38	ENGINEROOM MESSENGER	3
39	SSTG SWBD OPERATOR	3
40	GYRO WATCH	2
41	AFTER STEERING	2

needed to get a ship of the Adams Class underway. These forty one positions are considered the most important to get the ship underway with duty section manning and no other outside assistance. The functional positions are listed in table I along with the initial strengths assigned to each position from a typical duty section. A brief description of each functional position is included in appendix B.

Another realistic aspect of initial strengths is that the engineers (positions 30-38) with a steaming (operating) engineering plant are in a two-section inport watchbill.

3. Initial Materiel Strength

In order to keep the materiel analysis simple, only ten materiel functions were included in the base case mission. These ten materiel functions provide a simplified breakdown of the equipment needed for various functions of the base case mission. The materiel functions listed are materiel equipment configurations common to all Adams Class Destroyers. The materiel items being considered for the destroyer are listed in table II along with the repair times for light and moderate damage.

There are two firerooms with two boilers each on this class of ship. The repair time for light damage of five minutes was small due to the many backup systems located in the firerooms for each boiler. By attempting to keep materiel analysis simple, the MET buildup would be very general. A fireroom or engineroom usually has two to three times the equipment necessary to keep itself considered as operational for this scenario. Light damage therefore would usually be handled by starting another piece of machinery and isolating the affected machine for repair later. This assumption is in contrast to the normal AMORE requirement of having mission essential teams consist of the minimum required to complete the mission. Moderate damage repair time would be applicable to machinery that would require immediate repair because no backup exists for the degraded materiel.

TABLE II

INITIAL MATERIEL AND REPAIR TIMES

MATERIEL DATA

TYPE	NAME	INITIAL SUPPLY	LIGHT REPAIR TIME	MODERATE REPAIR TIME
1	FWD FIREROOM	1	5	60
2	AFT FIREROOM	1	5	60
3	FWD ENGINEROOM	1	5	60
4	AFT ENGINEROOM	1	5	60
5	STEERING	2	2	25
6	ELECTRICAL DISTRIBUTION	4	2	30
7	JV PHONE CIRCUIT	1	2	20
8	JA/JL PHONE CIRCUIT	1	2	20
9	GYRO	2	1	90
10	RADAR	1	15	90

Time in Minutes

Two steering motors are onboard this type of ship, and four ship service turbine generators each capable of providing enough electricity for the ship in this base case. The phone circuits are independent, but possess the ability to augment each other. Two gyros are onboard this type of ship and usually one surface search radar. The repair times for all the equipment is subjective and admittedly optimistic. As with propulsion, light damage for this example reflects the crew starting backup equipment, and moderate damage reflects immediate attempts at repair.

4. Mission Essential Teams

Personnel and materiel needed to perform each function are divided into teams. Teams are constructed with the assets needed for various levels of unit operational capability, and thus represent increments of increasing capability. Essential teams are defined as "the breakdown of the unit into components (teams) which contain only the personnel and materiel that are absolutely necessary to mission accomplishment." [Ref. 2: pp. 1-6] As stated earlier, simple materiel analysis conducted here may inclued backup flexibility which contains more than that which is absolutely necessary.

For Navy application, another change in the normal AMORE methodology is needed. Mission Essential Teams are usually considered to represent equal, or nearly equal, slices of unit capability. This is due to the independent nature of mission essential teams for most Army applications. For this application, the first mission essential team is established with a capability to accomplish the mission. However, satisfactory completion of the mission is highly in doubt due to the difficulty of severly limited command and control, mobility, and navigational capabilities. The more mission essential teams that are reconstructed for the base case, the more likely the mission of quickly getting underway will be realized.

a. Personnel

The personnel for the base case example were broken into seven essential teams and are displayed in table III. A first essential team is made up of those personnel required to get the ship underway as quickly as possible. Safety isn't the main concern nor is having to navigate the ship down a long channel. The engineering plant is one boiler and one engine. Team one is the minimum needed to get the ship underway quickly. For this initial example 18 personnel were determined to be the absolute minimum required with the engineering plant configuration as metioned above and a standard destroyer mooring of six lines.

TABLE III

PERSONNEL MISSION ESSENTIAL TEAMS

PERSONNEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 1	ESSENTIALS FOR TEAM 2	ESSENTIALS FOR TEAM 3	ESSENTIALS FOR TEAM 4
1	1	1	1	1
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	1	1	1	1
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	1	1	1	1
17	0	0	0	0
18	0	1	1	1
19	1	1	1	1
20	1	1	1	1
21	1	1	1	1
22	1	1	1	1
23	1	1	1	1
24	1	1	1	1
25	1	1	1	1
26	0	0	0	0
27	0	0	0	0
28	0	0	0	0
29	0	0	0	0
30	0	1	1	1
31	1	1	1	2
32	1	1	1	2
33	1	1	1	2
34	0	0	1	2
35	1	1	1	2
36	1	1	1	2
37	1	1	1	2
38	0	0	1	2
39	1	1	1	1
40	0	0	1	1
41	1	1	1	1

Table III (cont'd.) PERSONNEL MISSION ESSENTIAL TEAMS

TASKS	ESSENTIALS FOR TEAM 5	ESSENTIALS FOR TEAM 6	ESSENTIALS FOR TEAM 7
1	1	1	1
2	0	0	1
3	1	1	1
4	0	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	0	0	1
11	0	0	1
12	0	0	1
13	0	0	1
14	0	0	1
15	0	0	1
16	1	1	1
17	1	1	1
18	1	1	1
19	1	1	1
20	2	2	2
21	2	2	2
22	2	2	2
23	2	2	2
24	2	2	2
25	2	2	2
26	1	1	1
27	1	1	1
28	0	1	1
29	0	1	1
30	1	1	1
31	2	2	2
32	2	2	2
33	2	2	2
34	2	2	2
35	2	2	2
36	2	2	2
37	2	2	2
38	2	2	2
39	1	1	1
40	1	1	1
41	1	1	1

Team two is cumulative and contains personnel who increase command and control capability. Being cumulative means that with team two the mission has additional personnel available. Or put another way, both team one and team two are being utilized to accomplish the mission. The overall assumption here is that with more personnel the likelihood of mission success will increase.

Team two adds the Engineering Officer of the Watch position (EOOW), as well as that of the 1JV phone talker on the forecastle. The addition of the phone talker in team two makes it easier and quicker for the Officer Of the Deck (OOD) to relay line handling orders and obtain information from the forecastle. Otherwise, this type of information flow would have involved the OOD and personnel on the forecastle communicating information over a fair distance with their voices. This makes communication more difficult and error-prone. Any information to or from the fantail (furthermost back of ship where line handlers are) would have been impossible. Adding the Engineering Officer Of the Watch (EOOW) to team two was done to better coordinate and control the engineering function. This position wasn't required in team one due to the assumption that if the EOOW didn't arrive on station the Machinist Mate Of the Watch (MMOW) would be able to fill in for the EOOW as well as do his own job.

As additional teams are added, it can be seen that with only team ONE the ship is capable of getting underway but with the additional teams, the ship is even more capable of getting underway or getting underway more safely.

Team three adds two engineering messengers, one for the fireroom and one for the engineroom. This adds a better monitoring capability for the two main propulsion spaces but still only gives the ship a one shaft capability.

Team four adds the additional engineering personnel that give the ship the two engines with two boilers, and thereby increasing capability and flexibility. Team five adds additional command and control personnel as well as visual navigation personnel and additional personnel to assist with line handling. The additional line handlers would allow the ship to now recover the lines instead of cutting them.

Teams six and seven add personnel to communicate with radio and to navigate with radar as a backup to visual navigation. More personnel are added as backup to the earlier essential team personnel and now the personnel of the duty section are exhausted.

b. Materiel

Seven mission essential teams of materiel were set up. Team one provided one fireroom and one engineroom in order to provide the ship with the capability to get underway with one engine. Also included in team one was the electrical distribution system, the ship steering system, and the 1JV phone circuit.

No other machinery was added until team four when the other fireroom and engineroom were added to coincide with the personnel of mission essential team four that provided additional engineering flexibility. Team five added the JA/JL phone circuit and electronic gyro to coincide with the personnel who were now assisting the OOD with visual navigation and team six added radar for the combat information center (CIC) team to conduct surface radar navigation and surface shipping surveillance. The construction of the seven mission essential teams for this base case is displayed in table IV.

TABLE IV

MATERIEL MISSION ESSENTIAL TEAMS

MATERIEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 1	ESSENTIALS FOR TEAM 2	ESSENTIALS FOR TEAM 3	ESSENTIALS FOR TEAM 4
1	1	1	1	1
2	0	0	0	1
3	1	1	1	1
4	0	0	0	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0

TASKS	ESSENTIALS FOR TEAM 5	ESSENTIALS FOR TEAM 6	ESSENTIALS FOR TEAM 7
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	0	1	1

5. <u>Probability of Personnel Degradation</u> (<u>Losses or Absentees</u>)

The next input requirement is the personnel degradation. This is a probability of attrition for each personnel position. Personnel attrition doesn't necessarily have to reflect a combat casualty. It could be a man missing his assignment due to confusion, being ill that day, or being injured in an accident on his way to station.

For this base case scenario an arbitrary 30% probability degradation (PD) for personnel was applied. This 30% was selected so as to insure a full range of output for demonstration purposes. The actual probability of degradation applied by any AMORE user would be determined by the scenario envisioned. Also the probability of degradation for personnel or materiel can be entered into the model separately with different values for each individual asset. Many combat simulations state that 30% attrition is enough to consider a unit "out" or needing replacement.

6. Transferability

a. Personnel

The next step was to design the personnel transfer matrix. A portion of this matrix for the forty one positions discussed earlier is shown in table V The complete transfer matrix is shown in appendix B. The times are in minutes. When there is only a period (".") the positions are considered not transferable. For instance, position number 8 is the position of HELM, which is the function of steering the ship. Moving across the matrix on row 8 shows that this man cannot transfer into position 1 or 2 which are the OOD (Officer of the Deck) or JOOD (Junior Officer of the Deck) but, in 1 minute, he could substitute for starboard bearing taker (column 5) on the starboard bridge wing.

The times selected for the transferabilities are the expected time it would take to transfer to, and function at, the new positions. The transfer times are one of the most subjective portions of the AMORE input.

TABLE V

TRANSFER MATRIX OF PERSONNEL FUNCTIONS

TRANSFER MATRIX FOR PERSONNEL

		1	2	3	4	5	6	7	8	9	10
1	OOD	0	0	5	5	1	1	0	1	1	1
2	JOOD	1	0	1	1	1	1	1	1	1	1
3	NAVPLOT1	.	.	0	0	1	1	5	1	1	1
4	NAVPLOT2	.	.	0	0	1	1	5	1	1	10
5	STB BRG	.	.	5	5	0	1	.	1	1	1
6	PORT BRG	.	.	5	5	1	0	.	1	1	1
7	BMOW	.	.	.	.	1	1	0	0	0	0
8	HELM	.	.	.	.	1	1	5	0	0	0
9	LEE HELM	.	.	.	.	1	1	5	0	0	0
10	BRIDGE STAT BOARD	.	.	.	.	1	1	5	0	0	0
11	CIC SUPERVISOR	.	.	1	1	1	1	.	5	1	1
12	CIC RADAR NAV PLOT	.	.	1	1	1	1	.	1	1	1
13	SPS 10 RADAR NAV	.	.	1	1	5	5	.	5	2	1
14	RADAR SURFACE SEARCH	.	.	10	10	5	5	.	10	10	5
15	NC2/DRT PLOT	.	.	.	.	5	5	.	5	5	3
16	1JV BRIDGE PHONE	.	.	.	.	10	10	.	1	1	1
17	JA/JL BRIDGE PHONE	.	.	.	.	10	10	.	1	1	1
18	1JV FORECASTLE	.	.	.	.	15	15	.	5	5	5
19	1 JV FANTAIL	.	.	.	.	.	.	.	.	.	.
20	LINE 1 NON TECH PERS	.	.	.	.	.	.	.	10	5	5
21	LINE 2 NON TECH PERS	.	.	.	.	.	.	.	15	5	5
22	LINE 3 TECH PERS	.	.	.	.	5	5	.	.	.	5
23	LINE 4 NON TECH PERS	.	.	.	.	.	.	.	10	8	5
24	LINE 5 NON TECH PERS	.	.	.	.	.	.	.	.	.	5
25	LINE 6 TECH PERS	.	.	.	.	.	.	.	5	5	5
26	1ST LT FORECASTLE	.	.	.	.	5	5	5	5	5	5
27	OIC/CPO AFT LINES	.	.	.	.	.	.	.	.	.	5
28	RADIO SUPERVISOR	.	.	.	.	.	.	.	.	.	.
29	RADIO ASSISTANT	.	.	.	.	.	.	.	.	.	.
30	EOOW	.	.	.	.	.	.	.	.	.	.
31	BTOW	.	.	.	.	.	.	.	.	.	.
32	UPPER LEVELMAN	.	.	.	.	.	.	.	.	.	.
33	BURNERMAN	.	.	.	.	.	.	.	.	.	.
34	FIREROOM MESSENGER	.	.	.	.	.	.	.	.	.	.
35	MMOW	.	.	.	.	.	.	.	.	.	.
36	LOWER LEVELMAN	.	.	.	.	.	.	.	.	.	.
37	THROTTLE	.	.	.	.	.	.	.	.	.	.
38	ENGINEROOM MESSENGER	.	.	.	.	.	.	.	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	.	.	.	.	.
40	GYRO WATCH	.	.	.	.	.	.	.	.	.	.
41	AFTER STEERING	.	.	.	.	.	.	.	10	10	.

b. Materiel

The materiel substitution matrix is designed similarly to the personnel matrix. The ability of materiel functions to substitute for other materiel functions is

TABLE VI

TRANSFER MATRIX OF MATERIEL FUNCTIONS

TRANSFER MATRIX FOR MATERIAL

	1	2	3	4	5	6	7	8	9	10
1 FWD FIREROOM	0	15	.	.	.	.	.	.	.	.
2 AFT FIREROOM	15	0	.	.	.	.	.	.	.	.
3 FWD ENGINEROOM	.	.	0	10	.	.	.	.	.	.
4 AFT ENGINEROOM	.	.	10	0	.	.	.	.	.	.
5 STEERING	.	.	.	.	0	.	.	.	.	.
6 ELECTRICAL DISTRIBUTION	.	.	.	.	.	0	.	.	.	.
7 JV PHONE CIRCUIT	.	.	.	.	.	.	0	15	.	.
8 JA/JL PHONE CIRCUIT	.	.	.	.	.	.	15	0	.	.
9 GYRO	.	.	.	.	.	.	.	.	0	.
10 RADAR	.	.	.	.	.	.	.	.	.	0

Where there are ".", no substitution is possible.

usually more limited than that of personnel. The materiel substitution matrix is shown in table VI.

There is one additional time that is entered which affects the time it takes for reconstruction of the unit and this is commander's decision delay time. This time reflects the time it would take for a person in charge to decide what transfer should take place and execute the necessary command to effect this. The delay time may be different for each personnel function and materiel item. The delay time may also differ for light and moderate damage to materiel as well.

B. AMORE OUTPUT

1. Unit Capability

TABLE VII

PERSONNEL, MATERIEL, AND TOTAL MINIMUM CAPABILITY

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.051	0.051	0.206	0.119	0.011	0.020
MINIMUM	0.029	0.035	0.206	0.119	0.011	0.020
0.250	0.686	0.100	0.269	0.131	0.200	0.107
0.500	0.874	0.076	0.423	0.149	0.389	0.143
0.750	0.874	0.076	0.543	0.133	0.503	0.131
1.000	0.909	0.055	0.651	0.119	0.629	0.114
1.250	0.909	0.055	0.714	0.111	0.686	0.107
1.500	0.909	0.055	0.714	0.111	0.686	0.107
1.750	0.909	0.055	0.714	0.111	0.686	0.107
2.000	0.909	0.055	0.737	0.111	0.709	0.107
2.250	0.909	0.055	0.737	0.111	0.709	0.107
2.500	0.909	0.055	0.737	0.111	0.709	0.107
2.750	0.909	0.055	0.754	0.100	0.726	0.097
3.000	0.909	0.055	0.754	0.100	0.726	0.097
3.250	0.909	0.055	0.754	0.100	0.726	0.097
3.500	0.909	0.055	0.754	0.100	0.726	0.097
3.750	0.909	0.055	0.754	0.100	0.726	0.097
4.000	0.909	0.055	0.754	0.100	0.726	0.097
INFINITY	0.909	0.055	0.754	0.100	0.726	0.097

ITERATIONS 25

The unit mean capabilities is the first output of the AMORE model. Table VII shows the unit capability after the first computer run. The first row of table VII shows the unit capability at time 0.00 in terms of personnel capability, materiel capability, and then a combined total value for the organization. At time 0 with a 30% degradation level the personnel capability is shown to be 0.051 or 5.1%

capable. Materiel at the same time is 20.6% capable. This 5.1% of personnel capability is about 5 percent of the mission essential team reconstruction. With seven mission essential teams this means 5.1% of seven teams.

The minimum (second row) is the capability evaluated immediately after the start of the reconstitution. All transfers are in progress, but only those with a total time of zero have been completed. [Ref. 2]

After 15 minutes, 0.25 hours in table VII, the average personnel capability was 68.6 percent with a standard deviation of 10.0 %. This resulted from the transfers of personnel that took place as established in table V The quickest (shortest) transfers were accomplished in the order of personnel MET (mission essential team) one to seven. Also within this same 15 minutes, on average, materiel recovered to 26.9% of capability.

The 68.6% personnel capability can be misleading. This represents 4.8 teams (68.6 times 7) being reconstructed on average over 25 iterations. To properly interpret the capability from reconstructing 4.8 teams, a capability contribution weight for each mission essential team must be determined. For this example, table VIII shows the percent contribution that each personnel mission essential team contributes to the overall successful mission accomplishment.

These percentage contributions are subjective. The additional command and control of MET two, three, and six were given the least weight at 5%. A weight of fifteen percent was assigned to team four for the additional maneuverability of the ship. A fifteen percent contribution was also given to team five for channel navigation assistance. Team seven (CIC personnel) was assigned a 10% contribution for radar backup for navigation (team 5) and shipping surveillance assistance for the OOD. Reconstructing 4.8 teams (68.6% of the teams) thus yields 81% unit capability.

TABLE VIII

PERSONNEL MET UNIT CAPABILITY PERCENTAGE CONTRIBUTION

MET 1	45%
MET 2	5%
MET 3	5%
MET 4	15%
MET 5	15%
MET 6	5%
MET 7	10%

At 0.25 hours, materiel shows a capability of 26.9%. Materiel usually reconstructs more slowly than personnel for two reasons: materiel has less substitutability and the transfer times are larger overall compared to personnel. But again, capability as shown in table VIII can be misleading.

The 26.9% represents 1.8 teams out of seven being reconstructed on the average. Refering back to table IV, as long as materiel MET one is reconstructed there are no other new requirements until materiel MET four. Having materiel MET one reconstructed would represent at least a contribution of 55%.(55% is contribution or the first 3 MET of table VIII).

Having 1.8 mission essential teams reconstructed when there are no additional materiel requirements until MET four, can be confusing. What must be remembered is that this analysis is for an average of 25 iterations. For one of the iterations materiel MET one was unable to be reconstructed and for five iterations materiel MET four had some needs. The 1.8 is an average of these 6 iterations. How this information was obtained will be explained in the next section.

The table VII shows Personnel recovering to 90.9% at 1 hour. This represents an average reconstruction of 6.36 teams. With 6 complete teams, the unit for this example is considered 90% capable when MET percentage contribution is applied. Materiel, however, recovers only to a 73.7% at two and a quarter hours. Again materiel appears to be more critical and the weak link for the example. (Most U.S. Army analysis finds materiel consistently showing less capability than personnel.)

2. Needs and Surplus (Chokepoints)

Table IX shows an optional part of the AMORE model output, the Sensitivity Analysis Needs and Surplus of the simulation. In AMORE term:.ology these needs are often refered to as chokepoints. The chokepoint analysis gives information about what has happened to the organization. It shows which personnel positions were exhausted and therefore did not allow the organization to recover to 100% capability. Sensitivity analysis is accomplished separatly for personnel and materiel.

In table IX each personnel task is displayed along with corresponding columns for needs and surplus of each position. "Team Four" appears at the top of the table. This is the MET at which the AMORE model "choked". Also notice at the bottom of these same columns, the number of iterations, (2 iterations for this example), is displayed. The model could only build the first three METs on two of the 25 iterations. It then went ahead and tried to build team four and kept track of needs and surpluses. Looking

TABLE IX

SENSITIVITY ANALYSIS NEEDS AND SURPLUS, PERSONNEL

SENSITIVITY ANALYSIS NEEDS AND SURPLUS
MISSION 1
PERSONNEL

TEAM 4

	NEEDS		SURPLUS	
TASK	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.50	0.71
3	0.00	0.00	0.50	0.71
4	0.00	0.00	0.50	0.71
5	0.00	0.00	0.50	0.71
6	0.00	0.00	1.00	0.00
7	0.00	0.00	1.50	0.71
8	0.00	0.00	0.00	0.00
9	0.00	0.00	2.00	0.00
10	0.00	0.00	1.50	0.71
11	0.00	0.00	0.00	0.00
12	0.00	0.00	0.50	0.71
13	0.00	0.00	1.00	0.00
14	0.00	0.00	0.50	0.71
15	0.00	0.00	1.00	0.00
16	0.00	0.00	0.00	0.00
17	0.00	0.00	0.50	0.71
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00
20	0.00	0.00	5.00	0.00
21	0.00	0.00	3.50	0.71
22	0.00	0.00	3.00	1.41
23	0.00	0.00	3.00	1.41
24	0.00	0.00	3.50	0.71
25	0.00	0.00	4.00	1.41
26	0.00	0.00	0.50	0.71
27	0.00	0.00	0.50	0.71
28	0.00	0.00	0.50	0.71
29	0.00	0.00	1.50	0.71
30	0.00	0.00	0.00	0.00
31	0.00	0.00	0.00	0.00
32	1.00	1.41	0.00	0.00
33	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00
35	0.50	0.71	0.00	0.00
36	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00
39	0.00	0.00	1.50	0.71
40	0.00	0.00	0.50	0.71
41	0.00	0.00	1.00	0.00

NUMBER OF ITERIONS 2.

down the average needs column, positions 32 (BTUL) and 35 (MMOW) were needed in order to complete team four.

A value of 1.00 for position 32 (BTUL) represents an average need of one position 32 for two iterations. This need is occuring on the attempt to reconstruct MET four. Table III showed that at MET four, two people were needed to fill position 32. On both attempts to build MET four, one position 32 was not filled. The value of 0.50 for position 35 means much the same thing: for two iterations an average of 0.50 position 35's were not filled. This means on one of the two iterations when position 32 was not filled, position 35 was fully filled (MET four requires 2 personnel at position 35) and on one of the iterations when one person was needed for position 32, one person was needed for position 35 as well.

Another optional AMORE output, the Sensitivity Analysis Assignment Matrix, can help the analyst determine what caused the need. This output will be discused in the next section.

The surplus column shows the surplus personnel available during the 2 iterations when only three teams could be built. For instance, position 25 was surplus at a value of 4.00. This value of four persons is possible because the surplus, like needs, is an average. On the two occasions there was an average of four extra position 25 personnel.

The sensitivity analysis continues for the remaining iterations. Table X shows that on eight of the iterations, the model choked trying to build the seventh MET. As can be seen in table X position 1, 2 and 11 caused this to happen.

At the end of the sensitivity analysis computer output, an average surplus of each position is displayed for the number of iterations that all mission essential teams were reconstructed. Table XI displays this average surplus

TABLE X

SENSITIVITY ANALYSYS, PERSONNEL CONTINUED

SENSITIVITY ANALYSIS NEEDS AND SURPLUS
MISSION 1
PERSONNEL

TEAM 7

	NEEDS		SURPLUS	
TASK	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	.38	0.52	0.00	0.00
2	.50	0.53	0.00	0.00
3	.00	0.00	0.00	0.00
4	.00	0.00	0.00	0.00
5	.00	0.00	0.00	0.00
6	.00	0.00	0.00	0.00
7	.00	0.00	0.00	0.00
8	.00	0.00	0.00	0.00
9	.00	0.00	0.13	0.35
10	.00	0.00	0.13	0.35
11	.50	0.53	0.00	0.00
12	.00	0.00	0.00	0.00
13	.00	0.00	0.00	0.00
14	.00	0.00	0.00	0.00
15	.00	0.00	0.00	0.00
16	.00	0.00	0.00	0.00
17	.00	0.00	0.00	0.00
18	.00	0.00	0.00	0.00
19	.00	0.00	0.00	0.00
20	.00	0.00	1.13	1.25
21	.00	0.00	2.50	1.60
22	.00	0.00	0.13	0.35
23	.00	0.00	3.00	1.60
24	.00	0.00	2.25	0.89
25	.00	0.00	1.13	1.46
26	.00	0.00	0.00	0.00
27	.00	0.00	0.00	0.00
28	.00	0.00	0.00	0.00
29	.00	0.00	0.25	0.46
30	.00	0.00	0.00	0.00
31	.00	0.00	0.25	0.46
32	.00	0.00	0.13	0.35
33	.00	0.00	0.50	0.93
34	.00	0.00	0.63	0.74
35	.00	0.00	0.25	0.46
36	.00	0.00	0.13	0.35
37	.00	0.00	0.38	0.52
38	.00	0.00	0.25	0.46
39	.00	0.00	1.00	0.76
40	.00	0.00	0.63	0.52
41	.00	0.00	0.75	0.46

NUMBER OF ITERATIONS 8.

for the base case. Note that for 15 of the 25 iterations all mission essential teams were reconstructed even with a probability of degradation of 30% for all personnel.

Table XII shows the sensitivity analysis needs and surplus for materiel. The same type of information is displayed as for personnel, but in addition, materiel positions are also displayed with light and moderate damage. The first ten rows represent materiel that is a total loss. Table XII shows that materiel chokes once trying to build team one. Though not displayed here, materiel choked for 5 iterations attempting to reconstruct team four, for 4 iterations on MET five, two iterations on team six, and was able to build every MET 13 times.

3. Sensitivity Analysis Assignment Matrix Output

Table XIII shows the assignment matrix output. The results displayed in table XIII are also optional for an AMORE simulation. Assignment matrices for each mission consist of the average survivors for those iterations used to build a particular maximum number of teams. When MET four choked for the two iterations (from table IX), table XIII shows what substitutions had been made to build the three MET up to that point.

In the first group of columns (3 by 7 matrix under first dotted line) task 1 has a value of 1.00 (asterick next to number referred to here). This represents the OOD (task 1) substituting for only himself. The second group of columns (group under second dotted line), shows that task seven under column eight has a value of 0.50 and task eight under column eight has a value of 0.50. This means that on the average when three mission essential teams could be built, 0.5 of the time position eight was filling in for itself (didn't suffer any degradation) and 0.5 of the time a position seven person was filling this position.

TABLE XI

SENSITIVITY ANALYSIS SURPLUS WITH ALL MET RECONSTRUCTED

SENSITIVITY ANALYSIS NEEDS AND SURPLUS CONTINUED
MISSION 1
PERSONNEL

AFTER LAST TEAM

	SURPLUS	
TASK	AVERAGE	ST. DEVIATION
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.07	0.26
8	0.00	0.00
9	0.00	0.00
10	0.27	0.46
11	0.00	0.00
12	0.00	0.00
13	0.00	0.00
14	0.00	0.00
15	0.00	0.00
16	0.00	0.00
17	0.00	0.00
18	0.00	0.00
19	0.00	0.00
20	1.87	1.81
21	3.20	1.37
22	0.33	0.49
23	2.80	1.21
24	3.20	0.77
25	1.80	1.42
26	0.00	0.00
27	0.00	0.00
28	0.00	0.00
29	0.53	0.52
30	0.00	0.00
31	0.07	0.26
32	0.20	0.41
33	0.67	0.72
34	0.87	0.74
35	0.13	0.35
36	0.20	0.41
37	0.40	0.63
38	0.47	0.52
39	0.87	0.92
40	0.47	0.52
41	0.53	0.52

NUMBER OF ITERATIONS 15.

TABLE XII

SENSITIVITY ANALYSIS NEEDS AND SURPLUS, MATERIEL

SENSITIVITY ANALYSIS NEEDS AND SURPLUS
MISSION 1
MATERIEL

TEAM 1

	NEEDS		SURPLUS	
TYPE	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	1.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	1.00	0.00
5	0.00	0.00	1.00	0.00
6	0.00	0.00	3.00	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
9	0.00	0.00	2.00	0.00
10	0.00	0.00	0.00	0.00
LIGHT				
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00
MODERATE				
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00
8	0.00	0.00	1.00	0.00
9	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00

NUMBER OF ITERATIONS 1.

For the base case, the task seven substitute could have moved from his MET, which was MET five (table III), or

TABLE XIII

SENSITIVITY ANALYSIS ASSIGNMENT NATRIX

SENSITIVITY ANALYSIS ASSIGNMENT MATRIX
MISSION 1
PERSONNEL

TEAM 3

TASK	1	2	3	4	5	6	7
1	1.00*	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TASK	8	9	10	11	12	13
1	0.00	0.00	0.00	0.00	0.00	0.00
7	0.50	0.00	0.00	0.00	0.00	0.00
8	0.50	0.00	0.00	0.00	0.00	0.00

TASK	27	28	29	30	31	32	33
31	0.00	0.00	0.00	0.50	1.00	0.50	0.00
32	0.00	0.00	0.00	0.00	0.00	0.50	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00	1.00
34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	0.00	0.50	0.00	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TASK	34	35	36	37	38	39
31	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00	0.00	0.00
34	1.00	0.00	0.00	0.00	0.00	0.00
35	0.00	1.00	0.00	0.00	0.00	0.00
36	0.00	0.00	0.50	0.00	0.00	0.00
37	0.00	0.00	0.50	1.00	0.00	0.00
38	0.00	0.00	0.00	0.00	1.00	0.00
39	0.00	0.00	0.00	0.00	0.00	1.00

more likely came from the initial strength pool. That is to say, in personnel MET construction only one person is required to fill the functions of task seven and eight. But as table I initial showed earlier, the initial strength of position seven was two and for position eight was one. There was an extra position seven person assigned to the unit. If this person wasn't attrited he would be a most logical substitution.

As table XIII demonstrates, analysis of the optional computer output can show substitutions that wouldn't be obvious from table IX. Without this additional information the analyst would have been unaware of substitutions between the BMOW and Helm positions (positions 7 and 8).

4. AMORE Outputs Summarized

For unit analysis, the AMORE inputs must be totally understood in order to understand the AMORE outputs. The first product is labeled "unit capability" and is a percentage of mission essential team reconstruction. If the MET are equal or nearly equal contributors then this computer output represents unit capability as labeled. If MET are not equal contributors then additional calculations must be accomplished to determine unit capability. The optional computer outputs of sensitivity analysis needs and surplus and sensitivity analysis assignment matrix should always be used to best understand what is happening to the unit. Without the optional outputs much misunderstanding could occur. The optional outputs also provide information for planning changes in manning or training policies in order to improve the capability of the organization.

III. AMORE APPLICATION TO INPORT DUTY SECTION

Analysis of all the outputs showed this organization to be sensitive at the OOD, JOOD, CIC SUPERVISOR, BTUL, and MMOW positions. Improvements in the unit's capability will be attempted by reducing the sensitivity for the two officer command and control postions as well as the engineering billets. The changes to the inputs of the model will represent policy or training implementations to improve the readiness of the unit.

If the capability configuration resulting from a particular set of resonable input parameters is too low to be acceptable, then the input information may be changed to improve capability. However, changes in the input data must reflect actual changes in training or manning characteristics or be consistent with reasonable proposals for policy change. Manipulation of input parameters which do not reflect the realities of environment and practical policy may give "comfortable" results but will not give useful guidance to analysts or policy makers.

A. CROSS-TRAINING

1. Changes in Substitutability

In order to improve officer command and control capability, the officer position of Engineering Officer Of the Watch (EOOW, task no. 30 in table V) was also allowed to be substituted for the OOD and JOOD positions. This position was assigned a ten minute transfer time. Ten minutes is the minimum time it would take an EOOW to turn over the watch to an MMOW and for the EOOW to get to the bridge and assume control of the ship for the OOD or JOOD. With this additional officer, capability moved up to 91.4% after one hour. See table XIV for capability analysis of this second computer run.

TABLE XIV

CAPABILITY WITH EOOW ADDED

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.017	0.016	0.217	0.113	0.011	0.014
MINIMUM	0.006	0.010	0.217	0.113	0.006	0.010
0.250	0.737	0.120	0.240	0.125	0.211	0.111
0.500	0.851	0.088	0.383	0.142	0.349	0.131
0.750	0.880	0.084	0.440	0.142	0.434	0.142
1.000	0.914	0.065	0.486	0.147	0.480	0.147
1.250	0.914	0.065	0.503	0.143	0.497	0.143
1.500	0.914	0.065	0.509	0.143	0.503	0.143
1.750	0.914	0.065	0.531	0.138	0.526	0.138
2.000	0.914	0.065	0.571	0.136	0.566	0.136
2.250	0.914	0.065	0.606	0.124	0.600	0.124
2.500	0.914	0.065	0.606	0.124	0.600	0.124
2.750	0.914	0.065	0.623	0.117	0.617	0.117
3.000	0.914	0.065	0.623	0.117	0.617	0.117
3.250	0.914	0.065	0.674	0.113	0.669	0.114
3.500	0.914	0.065	0.674	0.113	0.669	0.114
3.750	0.914	0.065	0.674	0.113	0.669	0.114
4.000	0.914	0.065	0.697	0.102	0.691	0.104
INFINITY	0.914	0.065	0.737	0.091	0.731	0.093

ITERATIONS 25

The overall capability of the organization improved given the assumption that either the Machinist Mate Of the Watch (MMOW) or the Boiler Technician Of the Watch (BTOW) were able to substitute for the EOOW and whoever substituted for the EOOW would in turn have someone capable of filling in for his position. The stringent PEB (Propulsion Examination Board) exams that all surface ships now have every 18 months make this an acceptable assumption.

Current U.S. Navy manning and training policy requires Officers assigned to engineering to become OOD qualified. This policy is different from that of other navies, such as the countries of the British Commonwealth, where Deck Officers and Engineering Officers specialize in these two different areas. The U.S. Navy Officer EOOW may or may not yet be qualified as an OOD but has had at least six months of training in seamanship prior to being assigned to any ship.

Another of the initial chokepoints was the MMOW. On this class of ship the EOOW usually is in the same compartment as one of the MMOWes and can easily substitute for this position. When the EOOW is an officer and can substitute for the OOD and MMOW, the need for both positions requiring a substitution can cause a problem. Usually the OOD has fewer other substitutes than the MMOW, and therefore the EOOW would substitute for the OOD. Both OOD and MMOW are in MET one for this example, but the initial strength for OOD is one and for MMOW it is three.

If an EOOW has the skills to substitute for both a MMOW and an OOD, a policy must be stated as to which position the EOOW should fill if both attrited positions are equally important. By equally important, it is meant that both the MMOW and OOD are in the same MET. Keeping the EOOW in engineering, as was in the base case, we now train some senior enlisted or intensify training for Officers or Chief Petty Officers in the 1ST LT and OIC/CPO AFT LINES positions.

Removing the transferability of EOOW to OOD and inserting instead the 1ST LT (job no. 26) and OIC/CPO AFT LINES (job no. 27) with a transferability of 20 minutes resulted in the capability analysis shown in table XV.

The transfer times were 20 minutes because the jobs of 1ST LT and OIC/CPO AFT LINES in this scenario are senior

TABLE XV

CAPABILITY WITH CHIEFS ONLY

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.051	0.049	0.171	0.097	0.006	0.010
MINIMUM	0.046	0.049	0.171	0.097	0.006	0.010
0.250	0.766	0.102	0.269	0.112	0.240	0.112
0.500	0.840	0.103	0.389	0.138	0.326	0.130
0.750	0.909	0.078	0.463	0.125	0.446	0.126
1.000	0.909	0.078	0.543	0.124	0.509	0.123
1.250	0.914	0.078	0.583	0.122	0.549	0.122
1.500	0.914	0.078	0.583	0.122	0.549	0.122
1.750	0.943	0.055	0.617	0.127	0.611	0.126
2.000	0.943	0.055	0.657	0.122	0.651	0.120
2.250	0.943	0.055	0.657	0.122	0.651	0.120
2.500	0.943	0.055	0.669	0.121	0.651	0.120
2.750	0.943	0.055	0.686	0.112	0.669	0.112
3.000	0.943	0.055	0.686	0.112	0.669	0.112
3.250	0.943	0.055	0.703	0.103	0.686	0.103
3.500	0.943	0.055	0.703	0.103	0.686	0.103
3.750	0.943	0.055	0.720	0.092	0.703	0.092
4.000	0.943	0.055	0.720	0.092	0.703	0.092
INFINITY	0.943	0.055	0.720	0.092	0.703	0.092

ITERATIONS 25

enlisted possibly resulting in longer transfer times. Senior enlisted would probably take a little more time to assume the function of OOD than another officer since officers have more formal schooling and probably more practice at being an OOD. The training proposed for this analysis is on-the-job training (OJT) by individual commands as was done briefly by the U.S. Navy in the mid 1970's.

The times of substitution of positions 26 and 27 are long, reflecting little practice and no formal schooling. The Chiefs here would probably be deck-oriented with possible Tug Master experience in their background. The time for transfer would depend on each duty section's officer or chief assigned to duty section 1ST LT or OIC/CPO AFT LINES. The officers usually assigned to these positions are very inexperienced.

As can be seen in table XV, 94.3% personnel capability is obtained at one and three quarters hours.

Combining the effects of both EOOW and 1ST LT or OIC/CPO AFT LINES had the surprising result of bringing the capability down from when just the 1ST LT and/or OIC/CPO AFT (hereafter called deck supervisors or chiefs) were the only new substitutions for OOD and JOOD. Table XVI shows the capability results with all three positions substitutable for OOD.

The sensitivity analysis needs and surplus computer output showed that with the three additional positions now substituting for OOD and JOOD, even more positions in engineering had needs. Giving the EOOW the authority to transfer for OOD of MET one caused problems when attempting to build the team for the second propulsion plant, MET four.

As was stated in chapter two, the engineers are already in two section (day on day off) duty. Having these personnel already standing more duty than any other types of personnel shows their criticality to a ship in the readiness status of this scenario. Keeping the officer EOOW more specialized in engineering gives the ship better capability provided a training policy of increased use of deck supervisors be used to substitute for command and control positions.

The data of the capabilities in tables VII, XIV, XV, XVI are displayed graphically in figure 3.1 for the first two hours. Figure 3.1 shows different strategies of transferability for the OOD and JOOD positions while maintaining all other inputs of the base case the same. The graph shows that adding the EOOW to the transfer matrix (line OODEOOW)

TABLE XVI

CAPABILITY WITH EOOW AND CPO

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.051	0.045	0.137	0.094	0.006	0.010
MINIMUM	0.051	0.045	0.137	0.094	0.006	0.010
0.250	0.709	0.124	0.234	0.120	0.223	0.119
0.500	0.829	0.116	0.337	0.127	0.314	0.123
0.750	0.846	0.104	0.417	0.127	0.371	0.118
1.000	0.909	0.078	0.469	0.126	0.429	0.118
1.250	0.909	0.078	0.520	0.110	0.480	0.105
1.500	0.909	0.078	0.543	0.115	0.503	0.111
1.750	0.937	0.055	0.554	0.119	0.543	0.114
2.000	0.937	0.055	0.554	0.119	0.543	0.114
2.250	0.937	0.055	0.594	0.116	0.583	0.111
2.500	0.937	0.055	0.617	0.118	0.594	0.115
2.750	0.937	0.055	0.634	0.111	0.611	0.107
3.000	0.937	0.055	0.634	0.111	0.611	0.107
3.250	0.937	0.055	0.634	0.111	0.611	0.107
3.500	0.937	0.055	0.634	0.111	0.611	0.107
3.750	0.937	0.055	0.634	0.111	0.611	0.107
4.000	0.937	0.055	0.634	0.111	0.611	0.107
INFINITY	0.937	0.055	0.674	0.103	0.651	0.101

ITERATIONS 25

eventually increased personnel capability, but at one half hour the capability was less than if the OOD and JOOD alone could transfer for each other (line OOD). This was due to the average engineering personnel needs having a greater effect at this point.

The OODCPO line also dips below the OOD line at one half hour. This is most likely due to the long transfer times of positions 26 and 27 (the chiefs) for the OOD and JOOD. Combining the EOOW and Chiefs to the transfer matrix for OOD and JOD is shown by the line labeled OODCPOEOOW. This line never achieves the capability of having just the

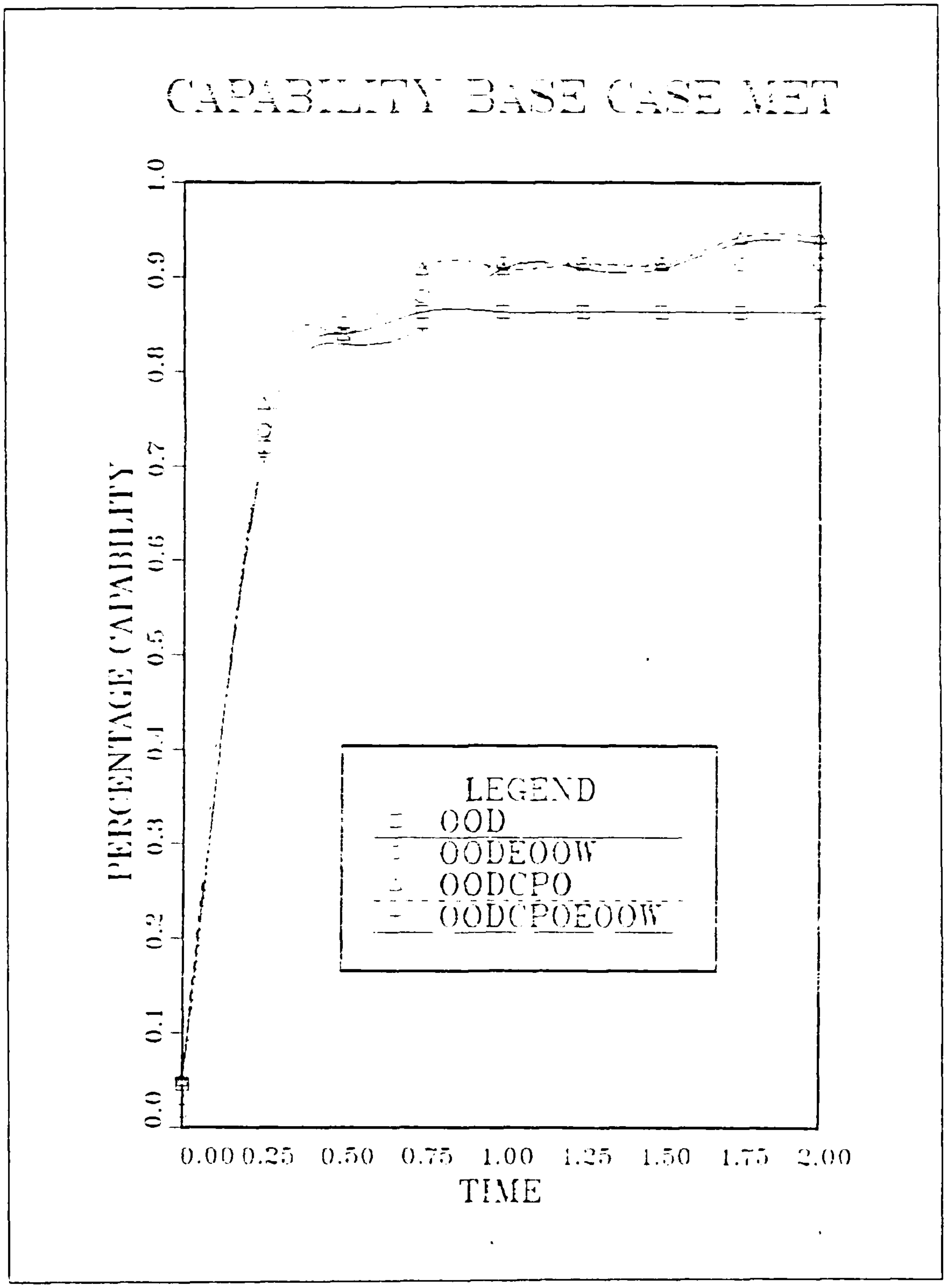

Figure 3.1 Capabilities With Differing Substitutions.

chiefs substitute for the OOD and JOOD because moving the EOOW out of engineering is less effective than leaving him in this department.

2. Varying Mission Essential Teams

Next the EOOW was moved to team four and therefore was only needed when both engineering plants were on line. During this time the MMOW would coordinate the one fireroom and engineroom himself.

TABLE XVII

EOOW AND CHIEFS BOTH IN TEAM 4

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.126	0.067	0.189	0.108	0.023	0.031
MINIMUM	0.051	0.049	0.189	0.108	0.017	0.030
0.250	0.731	0.116	0.257	0.114	0.251	0.113
0.500	0.869	0.097	0.371	0.131	0.371	0.131
0.750	0.926	0.066	0.429	0.141	0.429	0.141
1.000	0.949	0.055	0.537	0.125	0.537	0.125
1.250	0.949	0.055	0.577	0.122	0.577	0.122
1.500	0.949	0.055	0.663	0.122	0.663	0.122
1.750	0.949	0.055	0.663	0.122	0.663	0.122
2.000	0.949	0.055	0.680	0.113	0.680	0.113
2.250	0.949	0.055	0.720	0.104	0.720	0.104
2.500	0.949	0.055	0.760	0.092	0.754	0.091
2.750	0.949	0.055	0.760	0.092	0.754	0.091
3.000	0.949	0.055	0.760	0.092	0.754	0.091
3.250	0.949	0.055	0.783	0.090	0.777	0.089
3.500	0.949	0.055	0.783	0.090	0.777	0.089
3.750	0.949	0.055	0.783	0.090	0.777	0.089
4.000	0.949	0.055	0.783	0.090	0.777	0.089
INFINITY	0.949	0.055	0.783	0.090	0.777	0.089

ITERATIONS 25

Using the same types of parameters as were compared in table XIV and table XV, the capability matrix in table XVII was the result when both the EOOW (10 minutes transfer for OOD and JOOD) and the 1ST LT or OIC/CPO AFT (20 minutes transfer for the OOD and JOOD) were combined into the transfer matrix. Moving the EOOW to MET four represented the policy of having a MMOW trained to handle one plant underway propulsion requirements, and thereby reduced a position in MET two. This type of policy reduced the worth of an EOOW. With this change, the organization recovered better and more quickly. It resulted in a 94.9% capability at one hour as compared to 93.7% in one and three quarter hours. But again, analysis of sensitivity needs and surplus showed engineering chokepoints.

By keeping the EOOW position specialized in engineering, the unit reconstructs even better. As table XVIII shows, having more deck substitutes even at twice (20 minutes) the transfer time as EOOW (10 minutes), the unit is better off.

Figure 3.2 shows the capability outputs graphed when the MET construction had the EOOW in team four instead of team one. This strategy then analyzed the initial base case transfer matrix when only the OOD and JOOD could substitute for each other. Then analysis was conducted adding just the EOOW with a transfer time of 10 minutes for positions one and two, then just the chiefs with 20 minutes for positions one and two, and finally combining both EOOW and chiefs into the transfer matrix for the OOD and JOOD. This is a similar analysis to that conducted in section one of this chapter. All inputs were kept constant except changes to the transfer matrix after the EOOW was moved to MET four.

Again it was seen that keeping the EOOW in engineering and training the chiefs to be OOD's or JOOD's

TABLE XVIII

KEEPING EOOW IN ENGINEERING

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.126	0.067	0.189	0.108	0.023	0.031
MINIMUM	0.051	0.049	0.189	0.108	0.017	0.030
0.250	0.731	0.116	0.257	0.114	0.251	0.113
0.500	0.869	0.097	0.371	0.131	0.371	0.131
0.750	0.926	0.066	0.429	0.141	0.429	0.141
1.000	0.949	0.055	0.537	0.125	0.537	0.125
1.250	0.949	0.055	0.577	0.122	0.577	0.122
1.500	0.949	0.055	0.663	0.122	0.663	0.122
1.750	0.949	0.055	0.663	0.122	0.663	0.122
2.000	0.949	0.055	0.680	0.113	0.680	0.113
2.250	0.949	0.055	0.720	0.104	0.720	0.104
2.500	0.949	0.055	0.760	0.092	0.754	0.091
2.750	0.949	0.055	0.760	0.092	0.754	0.091
3.000	0.949	0.055	0.760	0.092	0.754	0.091
3.250	0.949	0.055	0.783	0.090	0.777	0.089
3.500	0.949	0.055	0.783	0.090	0.777	0.089
3.750	0.949	0.055	0.783	0.090	0.777	0.089
4.000	0.949	0.055	0.783	0.090	0.777	0.089
INFINITY	0.949	0.055	0.783	0.090	0.777	0.089

ITERATIONS 25

ultimately provided the best capability. This was true even when the EOOW was considered less valuable to engineering (moving the EOOW to MET four).

3. Varying MET Priority

An individual unit may desire to train in such a way as to change the way a mission is accomplished. In the base case, the mission essential teams had the ship mobility in MET one and MET four. What if getting the ship underway with only one engine isn't possible? The ability for a ship of this class to get underway without tugs will vary with

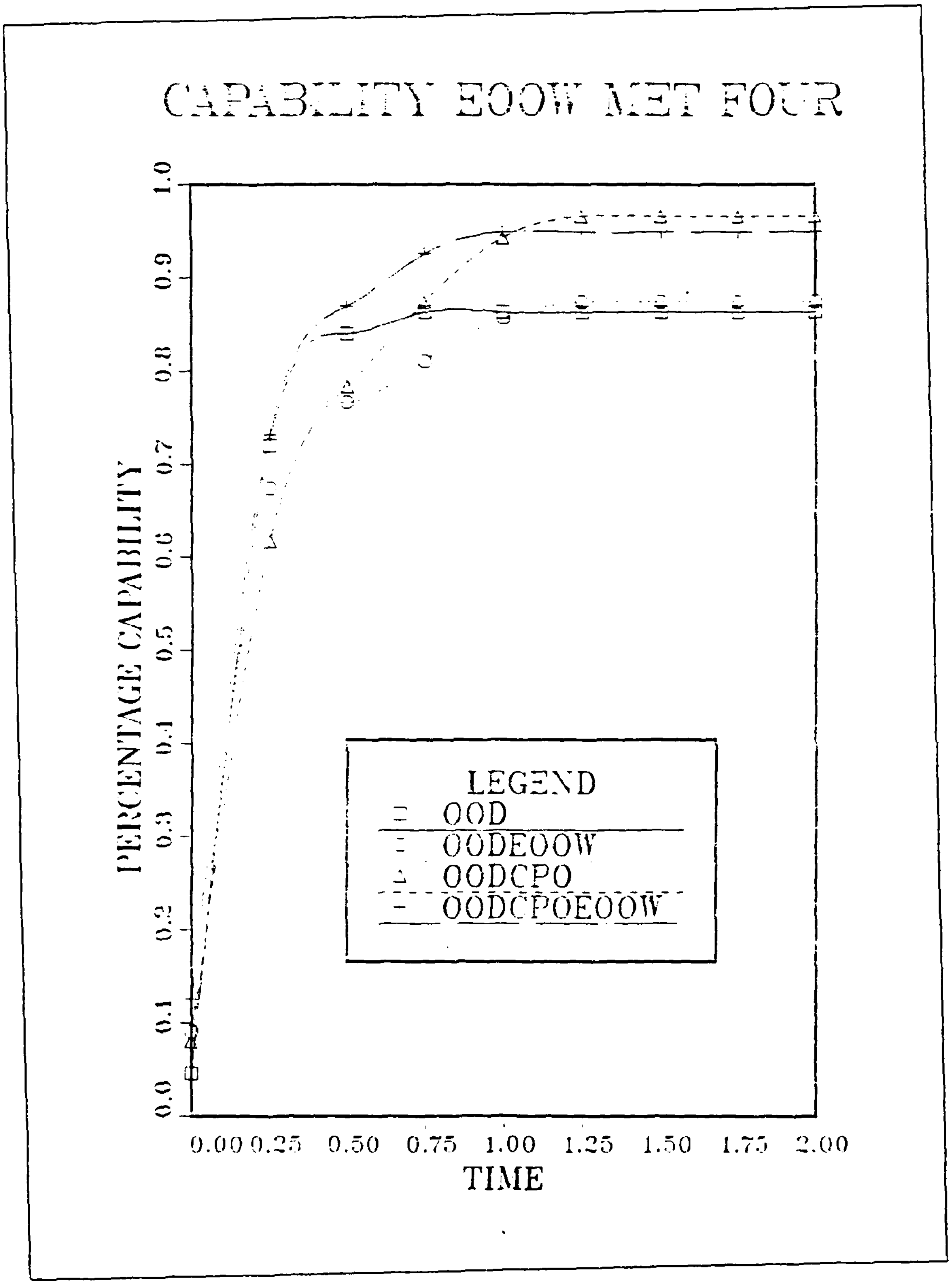

Figure 3.2 Capability EOOW Moved to MET Four.

ports and how the ship is moored. If the assets are available, getting two engines in operation isn't a difficult or a lengthy process.

In order to increase mobility the MET four positions 31 through 38, were placed in MET two. With all other inputs of the base case the same as was established in chapter two, 25 iterations were run. Table XIX shows the capability of the unit with an increased emphasis on mobility.

TABLE XIX

INCREASING IMPORTANCE OF MOBILITY

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.040	0.042	0.251	0.113	0.034	0.041
MINIMUM	0.034	0.041	0.251	0.113	0.034	0.041
0.250	0.629	0.152	0.360	0.130	0.269	0.123
0.500	0.766	0.139	0.509	0.125	0.446	0.138
0.750	0.766	0.139	0.566	0.128	0.474	0.141
1.000	0.766	0.139	0.577	0.131	0.486	0.145
1.250	0.766	0.139	0.617	0.127	0.520	0.143
1.500	0.766	0.139	0.617	0.127	0.520	0.143
1.750	0.766	0.139	0.617	0.127	0.520	0.143
2.000	0.766	0.139	0.617	0.127	0.520	0.143
2.250	0.766	0.139	0.617	0.127	0.520	0.143
2.500	0.766	0.139	0.640	0.119	0.543	0.138
2.750	0.766	0.139	0.640	0.119	0.543	0.138
3.000	0.766	0.139	0.640	0.119	0.543	0.138
3.250	0.766	0.139	0.651	0.122	0.554	0.141
3.500	0.766	0.139	0.651	0.122	0.554	0.141
3.750	0.766	0.139	0.651	0.122	0.554	0.141
4.000	0.766	0.139	0.651	0.122	0.554	0.141
INFINITY	0.766	0.139	0.651	0.122	0.554	0.141

ITERATIONS 25

Table XX shows a portion of the sensitivity analysis needs and surplus output for the increased mobility run. In table XX shows that for 3 iterations MET one couldn't be built due to the OOD and JOOD positions.

The 0.67 values for task 1 and 2 represent the OOD (task 1) and JOOD (task 2) positions not being filled for MET one, for two of the three iterations.

Table XXI shows that for another three iterations, MET two couldn't be built due to a shortage of engineering billets. The 0.33 values for tasks 30, 31, and 35 of table XXI represent each position not being filled for one of the three iterations that mission essential team two couldn't be built.

Increasing the emphasis on mobility brought the capability of the unit down after degradation. The positions that choked are roughly the same. In this basic model the officer command and control positions are sensitive as well as many of the engineering positions. Using the same change in substitutability as earlier, the deck supervisors were allowed to transfer for the OOD and JOOD, and the EOOW was kept in engineering. Table XXII shows the capability results. Capability only reached 78.9 percent in one and a half hours. This reflects an increased emphasis on MET two instead of four. Earlier the model had engineering needs at team four, and the percentage reconstruction needs were computed as team four of seven teams. Now these same needs are at team two instead of team four. This reflects a smaller percentage capability on the average and thus table XXII shows 78.9 percent where table XVIII showed 94.9 percent.

4. Probability of Degradation Change

The probability of personnel degradation may seem too high at 30%. Different degradation probabilities may

TABLE XX

SENSITIVITY ANALYSIS INCREASED MOBILITY

SENSITIVITY ANALYSIS NEEDS AND SURPLUS
MISSION 1
PERSONNEL

TEAM 1

	NEEDS		SURPLUS	
TASK	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	0.67	0.58	0.00	0.00
2	0.67	0.58	0.00	0.00
3	0.00	0.00	1.00	0.00
4	0.00	0.00	1.00	0.00
5	0.00	0.00	0.33	0.58
6	0.00	0.00	0.67	0.58
7	0.00	0.00	1.33	1.15
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.67	0.58
10	0.00	0.00	1.67	0.58
11	0.00	0.00	0.33	0.58
12	0.00	0.00	0.00	0.00
13	0.00	0.00	0.33	0.58
14	0.00	0.00	0.33	0.58
15	0.00	0.00	0.67	0.58
16	0.00	0.00	0.00	0.00
17	0.00	0.00	0.67	0.58
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00
20	0.00	0.00	3.67	1.53
21	0.00	0.00	5.00	1.00
22	0.00	0.00	3.67	0.58
23	0.00	0.00	3.00	1.00
24	0.00	0.00	4.00	1.00
25	0.00	0.00	2.00	1.73
26	0.00	0.00	0.33	0.58
27	0.00	0.00	0.00	0.00
28	0.00	0.00	0.33	0.58
29	0.00	0.00	1.33	1.15
30	0.00	0.00	0.00	0.00
31	0.00	0.00	1.33	0.58
32	0.00	0.00	1.33	0.58
33	0.00	0.00	1.33	0.58
34	0.00	0.00	2.33	0.58
35	0.00	0.00	1.00	1.00
36	0.00	0.00	0.67	0.58
37	0.00	0.00	1.67	1.15
38	0.00	0.00	1.00	0.00
39	0.00	0.00	1.33	1.15
40	0.00	0.00	1.67	0.58
41	0.00	0.00	0.33	0.58

NUMBER OF ITERIONS 3.

TABLE XXI

SENSITIVITY ANALYSIS IMCREASED MOBILITY

SENSITIVITY ANALYSIS NEEDS AND SURPLUS
MISSION 1
PERSONNEL

TEAM 2

	NEEDS		SURPLUS	
TASK	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	1.00	0.00
4	0.00	0.00	0.67	0.58
5	0.00	0.00	0.33	0.58
6	0.00	0.00	1.00	0.00
7	0.00	0.00	1.67	0.58
8	0.00	0.00	0.00	0.00
9	0.00	0.00	0.33	0.58
10	0.00	0.00	1.67	0.58
11	0.00	0.00	0.33	0.58
12	0.00	0.00	1.00	0.00
13	0.00	0.00	0.67	0.58
14	0.00	0.00	0.67	0.58
15	0.00	0.00	1.00	0.00
16	0.00	0.00	0.00	0.00
17	0.00	0.00	1.00	0.00
18	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00
20	0.00	0.00	3.67	1.53
21	0.00	0.00	4.00	1.00
22	0.00	0.00	3.33	1.15
23	0.00	0.00	2.67	0.58
24	0.00	0.00	3.67	2.08
25	0.00	0.00	2.33	1.15
26	0.00	0.00	0.33	0.58
27	0.00	0.00	1.00	0.00
28	0.00	0.00	1.00	0.00
29	0.00	0.00	1.00	0.00
30	0.33	0.58	0.00	0.00
31	0.33	0.58	0.00	0.00
32	0.00	0.00	0.00	0.00
33	0.00	0.00	0.00	0.00
34	0.00	0.00	0.00	0.00
35	0.33	0.58	0.00	0.00
36	0.00	0.00	0.00	0.00
37	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00
39	0.00	0.00	1.33	0.58
40	0.00	0.00	1.67	0.58
41	0.00	0.00	0.67	0.58

NUMBER OF ITERATIONS 3.

TABLE XXII

OOD AND CPO INCREASED MOBILITY

MEAN CAPABILITIES

TIME (HOURS)	PERSONNEL		MISSION 1 MATERIEL		MINIMUM	
0.000	0.006	0.010	0.206	0.094	0.006	0.010
MINIMUM	0.006	0.010	0.206	0.094	0.006	0.010
0.250	0.509	0.156	0.269	0.119	0.114	0.086
0.500	0.634	0.159	0.429	0.120	0.251	0.106
0.750	0.709	0.151	0.469	0.131	0.291	0.116
1.000	0.749	0.143	0.491	0.139	0.343	0.130
1.250	0.749	0.143	0.543	0.133	0.394	0.131
1.500	0.789	0.133	0.566	0.127	0.457	0.131
1.750	0.789	0.133	0.589	0.130	0.457	0.131
2.000	0.789	0.133	0.589	0.130	0.457	0.131
2.250	0.789	0.133	0.589	0.130	0.457	0.131
2.500	0.789	0.133	0.629	0.116	0.497	0.122
2.750	0.789	0.133	0.629	0.116	0.497	0.122
3.000	0.789	0.133	0.629	0.116	0.497	0.122
3.250	0.789	0.133	0.629	0.116	0.497	0.122
3.500	0.789	0.133	0.629	0.116	0.497	0.122
3.750	0.789	0.133	0.629	0.116	0.497	0.122
4.000	0.789	0.133	0.629	0.116	0.497	0.122
INFINITY	0.789	0.133	0.629	0.116	0.497	0.122

ITERATIONS 25

give vastly different results for the unit. Reducing the probability of degradation down only five percent to 25% provided the capability result in table XXIII. All other inputs were the same as the base case of chapter two. As can be seen in table XXIII the capability returns to 98.3% in one hour.

The sensitivity analysis output from this computer simulation showed that only the command and control positions 1,2, and 11 choked on the seventh MET for 3 iterations. What was surprising is that with a 5% drop in personnel attrition, no Engineering needs developed. in fact, all engineering positions except the EOOW were in surplus.

TABLE XXIII

CAPABILITY WITH DEGRADATION AT 25%

MEAN CAPABILITIES

MISSION 1

TIME (HOURS)	PERSONNEL		MATERIEL		MINIMUM	
0.000	0.080	0.055	0.194	0.099	0.046	0.049
MINIMUM	0.063	0.055	0.194	0.099	0.040	0.048
0.250	0.731	0.112	0.463	0.134	0.337	0.109
0.500	0.903	0.078	0.554	0.119	0.509	0.118
0.750	0.937	0.055	0.623	0.108	0.611	0.109
1.000	0.983	0.016	0.623	0.108	0.623	0.108
1.250	0.983	0.016	0.663	0.101	0.657	0.099
1.500	0.983	0.016	0.663	0.101	0.657	0.099
1.750	0.983	0.016	0.663	0.101	0.657	0.099
2.000	0.983	0.016	0.703	0.091	0.697	0.089
2.250	0.983	0.016	0.703	0.091	0.697	0.089
2.500	0.983	0.016	0.703	0.091	0.697	0.089
2.750	0.983	0.016	0.703	0.091	0.697	0.089
3.000	0.983	0.016	0.703	0.091	0.697	0.089
3.250	0.983	0.016	0.703	0.091	0.697	0.089
3.500	0.983	0.016	0.703	0.091	0.697	0.089
3.750	0.983	0.016	0.703	0.091	0.697	0.089
4.000	0.983	0.016	0.703	0.091	0.697	0.089
INFINITY	0.983	0.016	0.703	0.091	0.697	0.089

ITERATIONS 25

Obtaining five percent less casualties for engineering personnel isn't difficult if these personnel are instructed to remain inside the ship on their way to station in a hostile environment. This would reduce their probability of loss and would be a common reaction anyway.

Analysis of the sensitivity analysis assignment matrix for this computer run showed the OOD having a need due strictly to attrition, the JOOD position was substituting for the OOD or the Navplot2 position, which is in MET six while the JOOD is in MET seven. The CIC Supervisor (position 11) was substituting for the Navplot1 position. It was the JOOD and CIC Supervisor substituting for navigation plotters, positions 3 and 4, that caused mission essential team reconstruction to show needs at MET seven.

This simple demonstration shows that even small differences in probabilities of degradation can have large effects on considerationss for training and manning policies. Degradation probabilities can be input separately for individual positions as well.

B. SUMMARY OF AMORE MODEL CHANGES

Some strategies for capability enhancement of a naval destroyer after degradation were attempted. Officer command and control and engineering personnel chokepoints were changed in this chapter. Moving chokepoints was attempted by increasing the transferability of personnel. All of the changes to model input represented policy changes to an inport duty section. Having the chief petty officers be able to substitute for the OOD and JOOD reflects cross-training. Having the EOOW remain in engineering and not substitute for the OOD or JOOD represents increased specialization for this officer position. Analysis of increasing mobility into mission essential teams one and two represents a standard operation procedure of getting a ship underway with two engines more quickly than attempting to get underway with one. Different probabilities of degradation can be the result of protective measures for assets or differing variables of a hostile environment.

IV. CONCLUSIONS

The Analysis of Military Organizational effectiveness methodology was demonstrated for naval use. The methodology is effective at simulating how a unit would respond if degradation to personnel and materiel were to occur. It can identify the more critical skill requirements needed for an organization given specific missions.

A. SENSITIVITY ANALYSIS

1. Changes in Substitutability

Chapter three showed how changes in substitutability could reduce or change the needs of an organization. Changes in substitutability were reflected in training policies that would provide more substitutes for the command and control personnel. By exploring more than one training strategy, better solutions were found than were initially obvious.

Having only another officer, the EOOW, substitute for the OOD and JOOD resulted in an improvement in capability. Next, training senior enlisted, for instance Chief Petty Officer line handling supervisors, the capability again improved but even more so than with just the EOOW substituting for the OOD and JOOD. Combining all three positions for the OOD or JOOD (allowing positions 26, 27 and 30 substitute for positions 1 and 2) showed a less optimal policy because more engineering needs developed. Keeping the engineering officer in engineering and training chiefs for increased command and control, proved to be the overall best solution and more closely follows a new U.S. Navy Mid-Grade Officer career policy of increased specialization.

Increased specialization through increased experience in a specific knowledge area is an increasing policy trend of the U.S. Navy. A policy change of Surface Warfare Officers has been enacted in 1983 that requires mid-grade officers to tour in the same departments: operations, combat systems, or engineering. This policy provides increased specialization through emphasized training and experience in one department instead of several departments. In a letter from Deputy Chief of Naval Operations for Surface Warfare, Vice Admiral R.L. Walters, stated "Our enlisted need and expect competent leadership. This new initiative is intended to strengthen the Surface Warfare Officers' relationship with enlisted technicians and to provide a strong professional team of officers and enlisted who can keep a ship operating to design standards and be able to fight with unparalleled skill." [Ref. 3]

A proper mix of specialization and appropriate general knowledge is still the complicated answer to ship manning. Increased ability of certain critical skills can be more important in many situations than just overall ship knowledge. Initially increased specialization may not seem at all an appropriate solution, but as was seen here, specialization has merit even with simple analysis.

2. Changing Probability of Degradation

Different expected levels of attrition can effect training priorities differently. In chapter three it was seen that even a 5% lower attrition rate for personnel reduced all needs for engineering personnel.

B. DESIGN CHANGES

1. Changing Mission Essential Teams

Changing the priority, or order, of METs is a unit design change. The design change considered is compatible with established procedure in handling emergencies. Whether to just concentrate on one propulsion plant or have an EOOW present on a bridge are design considerations. A policy of having one or two engines in operation may depend on initial strengths available, probabilities of degradation, type of port the ship is moored, or many other ship or environmental considerations. Remaining mission capable but also finding ways to reduce resources in one area may free up assets for substitution to other areas of greater need. Moving the EOOW to MET four in chapter three made little difference and increasing emphasis on mobility made the engineering positions more critical.

C. RECOMMENDATIONS AND RESERVATIONS

1. Model Changes

Modifications of input and output to the computer simulation would make Amore much more useful. A recommended modification would be adding to the input the ability to weight the percentage of contribution of mission essential teams. This modification should also include an output of mission capability that ties together the weight of contribution of the teams along with the percentage of MET reconstruction. This would provide an output that would better display mission capability after reconstruction.

2. Training

Amore can assist a unit in recognizing its limited flexibility. With that knowledge a unit will be able to develop operating procedures and training policies to increase its flexibility. With Amore isolating potential choke areas, specific areas where cross-training could be most beneficial would be identified. Concentrating unit training on the skills that choke will increase the capability of the unit as soon as possible.

Communication of the results of Amore analysis to personnel could act as encouragement for personnel receiving cross-training. The increase in unit capability effectiveness through increased personnel transferability should be demonstrated to personnel who are required to put forth additional effort in cross-training. This is especially easy to accomplish if the analysis is being conducted at the unit level. When different probabilities of degradation to assets are simulated with the model, skill needs and surpluses are identified. The surpluses can show where supply availability exists for possible cross-training programs for skills that are needed.

3. Skill Requirements

The Amore methodology forces a unit to determine the most essential skills required. Once the more important skills are identified, the limited time available for training can be optimized. Skill requirements can change with missions. Also, improved technology can change or eliminate previously important personnel skills. Modernization overhauls and ship alterations accomplished during maintenance availabilities inport may alter skill requirements.

Having the Amore process established ahead of time for many emergency contingencies can save time by having a substitution matrix available as well as known to all personnel.

4. Nothing Stays The Same

The dynamic world environment, different personnel, materiel, and mission requirements, can be quickly analyzed with the Amore model. When the requirements or the assets of an organization change, the organization's priorities in training can change. Being able to identify quickly what cross-training program is most important is very valuable.

5. Attrition

Attrition does not always imply combat casualties. Personnel loss can occur due to leave, school training off ship, or unauthorized absence. A predetermined loss can be reflected through changes in initial strength assignment or by changes to the transfer matrix. Other non-combat attrition could result from new personnel being confused and showing up to fill the wrong team or just plain getting lost in the confusion that often results in emergency situations.

6. MET Contribution and Interdependence

Seldom, if ever, are the mission essential teams equal in contribution when an entire ship is analyzed. Not only do the contributions vary depending on the mission, but also a great interdependence of mission essential teams exists. For instance, detection and weapons teams require electrical power. This electrical power can only come from the engineering teams. Weapons and detection teams are more able to substitute for each other, but not for engineering teams when steam operated equipment is used. Gas turbine and remote operation technology of all Frigates, Destroyers, and Cruisers now under construction in the U.S. Navy may reduce the differences however.

Construction of mission essential teams for most warfare scenarios would require electrical generation ability as a first MET. But the contribution of this MET is difficult to determine. A unit with full engineering ability but with problems in weapons or detection ability would be less than 100% capable if any at-sea war missions were analyzed.

Because the Amore model is a tool available with microcomputer technology, it is available at the unit level. For some situations Amore is more useful in naval application than other unit capability models. This methodology is most useful when the contributions of mission essential teams are approximately equal. Even if teams are not equal in weight, there needs to be much duplication of assets so that, if one team cannot be reconstructed, mission accomplishment is still possible. An example of this was the underway scenario of the base case. The mobility mission essential teams were not both needed for mission accomplishment.

7. Future Skill Requirements

A ship of the Adams Class has many different readiness standards while inport. In increasing order of readiness, a ship can be in overhaul, maintenance availability in homeport, inport working up for deployment, or inport overseas. These various readiness statuses required different sets of skills. With Amore identifying the more critical skill requirements, a prioritized training plan can be developed to prepare personnel for increased levels of readiness. Training is often easier when the ship is in overhaul or other reduced levels of readiness.

8. Unit Design

Amore can help determine optimum manning for inport duty sections. Simulations of possible emergency contingencies of inport duty sections could identify the minimum skill functions required to perform various missions at a satisfactory level. This methodology could be used to update the number of possible inport duty sections for a ship. The number of duty sections would depend upon the readiness status which imposes mission requirements and the skill availability of the currently assigned crew. The skill availability is dynamic and varies due to experience, turnover, numbers of personnel at school, on leave, or absent for whatever reasons.

With different levels of inport readiness mentioned earlier, most ships have leave policy authorization amounts of 10%, 25% or 50% depending on operating schedule and holiday seasons. The effects of leave policies on duty sections and the resultant effect on ability to handle emergency situations can be analyzed. Other scheduled losses of personnel could be analyzed as well.

9. Reservations

Many assumptions for the base case were made by this author. The mission essential team construction and minimum skills required could have been different for different analysts. The times for transfer were very arbitrary as only aggregate abilities of observed typical personnel skill types were used. This thesis wasn't meant to be an argument for inport duty section manning needs and surpluses of an Adams Class Destroyer, but an argument for the possible use of Amore on this and similar classes of ships. For overall naval use Amore appears most useful for minor specific mission analysis such as inport duty section planning, rather than major at-sea warfare scenarios.

Recent naval battle scenarioes, such as the Falklands War, show that mission essential team reconstruction is often impossible if even one or two teams are attrited. A missile or bomb hit at various sections of the ship may represent only 10 to 20 percent attrition, but the ship will still sink. A hit to a ship even though initially causing low attrition can in itself change the mission of a ship from fighting to just trying to survive.

Substituting men and machinery for those that have suffered attrition is not a new idea for the Navy. For naval ship design and policies of manning; duplication, isolation, and separation of engineering, weapons, and detection systems are basic requirements. These have given many ships flexibility from designed backup systems as well as the ability to isolate and control any initial damage. The damage control organizational philosophy of isolating, controlling, and containing damage along with backups built into various systems provides navy ships with a large amount of resiliency.

The U.S. Navy often looks at teams as isolated components, each providing their ability to the overall capability of the ship. Degradation to one team (for instance an engineroom) would have casualty control procedures isolating or bypassing the compartment until repairs could be made. Because of the power generating capability of an engineroom and the electrical product of this team, which is required by other mission essential teams, any engineroom would be considered essential. But materiel design, operating procedures, and training drills currently are all practiced to give a ship nearly complete capability even if a vital (essential) team, such as an engineroom, were completely lost. Reconstruction of degraded assets isn't always the priority; backup and alternative procedures usually are. The Adams Class destroyer is a good example of multiple backup design and practice.

The interdependency of Mission Essential Teams and the difficulty in being able to determine contribution of each MET makes use of Amore difficult in Naval application.

Adding to the argument against naval use of Amore are single degradation hits that a ship can take, which in terms of attrition are small, but the effects to ship capability could be very large. The model itself appears to make the assumption that a substitution once complete gives a team the same capability as before degradation. Intuitively this doesn't appear to be always true.

D. FURTHER STUDY

Possible follow-on research with this methodology would probably best be approached as a group or team effort. With more experts of varied technical experience but similar platform experience an improved analysis of greater depth may be possible.

The assumptions made here were general and the analysis was primarily of personnel. Combining materiel and personnel may produce useful findings not observed with this simple analysis.

The strongest argument against further naval application of Amore is the problem of inter-dependency of mission essential team construction. This serious problem must be addressed. Also, providing a mechanism for weighting the contribution of each mission essential team should be accomplished prior to any further naval application.

APPENDIX A

EXAMPLE OF MISSION ESSENTIAL TEAMS OF U.S. ARMY TANK COMPANY

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
1. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask
2. Plt Sgt Tank Team	1 Platoon Sgt 1 Sr Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VDR-1 1 Alarm Chemical Agent Port Manpac 1 Tank 1 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
3. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask
4. Plt Ldr Tank Team	1 Platoon Ldr 1 Sr Gunner 1 Loader 1 Sr Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VRD-1 1 Alarm Chemical Agent Port Manpac 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask
5. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
6. Plt Sgt Tank Team	1 Platoon Sgt 1 Sr Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VDR-1 1 Alarm Chemical Agent Port Manpac 1 Tank 1 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask
7. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask
8. Company Commander Team	1 Company Commander 1 Sr Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Co Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
8. Company Commander Team continued		1 Elect Transfer Keying Device Device
9. Plt Ldr Tank Team	1 Platoon Ldr 1 Sr Gunner 1 Loader 1 Sr Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VRD-1 1 Alarm Chemical Agent Port Manpac 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask
10. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
11. Plt Sgt Tank Team	1 Platoon Sgt 1 Sr Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VDR-1 1 Alarm Chemical Agent Port Manpac 1 Tank 1 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask
12. Tank Team	1 Tank Commander 1 Gunner 1 Loader 1 Tank Driver	1 Filter Unit Gas Particulate 1 Tank 2 Speech Security Equipment (KY-57) 4 Chemical Biological Mask
13. Plt Ldr Tank Team	1 Platoon Ldr 1 Sr Gunner 1 Loader 1 Sr Tank Driver	1 Filter Unit Gas Particle 1 Radiac Set AN/VRD-1 1 Alarm Chemical Agent Port Manpac 1 Tank

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
13. Plt Ldr Team continued		2 Speech Security Equipment (KY-57) 4 Chemical-Bio Mask
14. Recovery Team	1 M1 Auto Mechanic 2 Recover Veh Operator 2 M1 Auto Mech	1 Radiac Meter Im-185/UD 1 Recover Vehicle 1 Tester Air Flow 1 Speech Security Equipment (KY-57) 5 Chemical-Bio Mask
15. Resupply Team	3 Hvy Vehicle Driver 3 Asst Hvy Veh Driver	1 Truck Cargo: 2 1/2 Ton 3 Truck Tank-Fuel 2500 Gal 2 Truck Cargo: 10 Ton 8x8 1 Speech Security Equipment (KY-57) 6 Chemical-Bio Mask
16. Headquarters Team	1 First Sgt 1 Supply Sgt 2 Tank Commander 1 Armorer	2 Alarm Chemical Agent Automatic 2 Trailer Cargo: 1 1/2 Ton

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
16. Headquarters Team continued	1 NBC OPS NCO	2 Truck Utility: 1/4 Ton 1 Charger Radiac Detector PP-4370 3 Speech Security Equipment (KY-57) 6 Chemical-Bio Mask
17. Maintenance Team	1 M1 Tank Main Supervisor 2 M1 Auto Mech 1 Tac Commo Mech 2 M1 Tank Turret	1 Carrier Personnel 1 Truck Cargo: 2 1/4 Ton with Winch 1 Shop Equipment Auto Main and Repair 1 Analyzer Set Engine 3 Tool Set, Mechanic 3 Tool Set, Turret 2 Speech Security Equipment (KY-57) 6 Chemical-Bio Mask

MISSION ESSENTIAL TEAMS	PERSONNEL	MATERIEL
18. XO Team	1 Executive Off.	1 XO Tank
	1 Gunner	1 Filter Unit Gas Particulate
	1 Tank Driver	1 Elec Transfer Keying Device
	1 Loader	1 Net Control Device NCDYX-15
		1 Radiac Set AN/VDR-1
		2 Radiac Meter IM-185/UD
		4 Speech Security Equipment (KY-57)
		4 Chemical-Bio Mask
		1 Charger Radiac Detector PP4370

APPENDIX B

DESCRIPTION OF PERSONNEL POSITIONS OF BASE CASE

These are definitions used in AMORE output tables. Each watchstation has title and what military rank usually would be in the position as well as a brief description of the watchstation.

1-OOD-Officer of the Deck- Officer in charge of the operation. Usually the senior personnel on the bridge. LT. (O-3) or LCDR (O-4).

2-JOOD-Junior Officer of the Deck- Usually the Officer conning (driving) the ship if the OOD is not. ENS (O-1) or LTjg (O-2).

3-NAVPLOT1-Navigation Plotter-Usually senior Quartermaster onboard. Does navigational plotting on chart on bridge, receiving input from bearing takers and also directs those bearing takers on what landmarks they are to take bearings on. This position coordinates entire visual navigation effort. QM1 (E-6) or QM2 (E-5) or QM3 (E-4).

4-NAVPLOT2- Navigational Plotter 2- Assistant to NAVPLOT1, would record bearings and assist in coordinating bridge wing bearing takers. QM2 (E-5) or QM3 (E-4).

5-STB BRG- Starboard Bridge Wing Bearing Taker- Quartermaster type duty, takes bearings with telescopic aledaide on fixed reference points on land such as water towers or prominent buildings.

6-PORT BRG- Port Bridge Wing Bearing Taker- Same as position 5 except on left side of the bridge.

7-BMOW- Boatswain Mate of the Watch- Supervises all enlisted bridge personnel, passes all word for OOD over 1MC. BM2 (E-5).

8-HELM- Helmsman- Steers the ship- Executes to all steering orders given by Conning Officer which is either OOD or JOOD.BM3 (E-4)or BMSN (E-3).

9- LEE HELM- Gives engine orders to EOOW via Engine Order Telegraph. BM-3 (E-4) BMSN (E-3).

10- BRIDGE STAT BOARD- Records all information from Combat Information Center on Status Board located in back of bridge. BMSN (E-3).

11-CIC RADAR PLOT- Plots radar navigation on chart, inputs provided from RADAR NAV with surface search radar, this plot is checked with the navigation plot on the bridge. OS2 (E-5).

12- RADAR NAV- Provides navigational input to NAV PLOT via surface search radar.OS3 (E-4).

13-CIC SURFACE SEARCH-Surface search operator that looks out for shipping provides warning for OOD via the BRIDGE STAT BOARD position. OS3 (E-4).

14- NC2 PLOT- Plots all shipping in real world framework, assists in warning OOD of possible shipping hazards via BRIDGE STAT BOARD position. OS3 (E-4).

15- BRIDGE 1JV PHONE-Phone talker on bridge in communication with Engineers and line handlers on forecastle and fantail. SN (E-3).

16-BRIDGE JL-JA PHONE- Phone talker on bridge with communication of Bearing takers and lookouts. SN (E-3).

17-FORECASTLE 1JV PHONE- Phone talker relaying information to and from Bridge and forward line handlers. SN (E-3).

18-FANTAIL 1JV PHONE - Phone talker after part of ship relaying information to and from the fantail and the bridge concerning line handling and any additional information useful to the OOD.

19-CIC SUP_ Cic Supervisor, coordinates all action going on in CIC including ship control, radar navigation, and any radio net circuits. OS1 (E-6) OS2 (E-5).

20-21-23-24-Line 1,2,4,5, NON TECH-Personnel initially assigned as line handlers that are normally assigned to non technical ratings such as Cook, Gunners Mates and ordinary Seaman. (E-5) through (E-1).

22-25-LINE 3,6 TECH- Personnel initially assigned as line handlers that are in technical type ratings such as ET-Electronic Technician etc. (E-6) through (E-2).

26- 1ST LT -Senior person on Forecastle supervisor of forward line handlers as well as anchors. Usually an Officer or Chief Petty Officer. (O-2) (O-1) (E-8) (E-7).

27-OIC/CPO AFT LINES- In charge of personnel manning the after lines. (E-8) (E-7).

28-RADIO SUP - Senior enlisted in Radio, Sets in radio transmitters for CIC and Bridge and covers Fleet Broadcast. (E-7) (E-6) (E-5).

29-RADIO ASSIST - Assistant to Radio Supervisor. (E-4) (E-3).

30-EOOW- ENGINEERING OFFICER OF THE WATCH-Overall in charge of all engineering propulsion and auxiliary. (O-4) through(O-1) (E-8) (E-7).

31-BTOW -BOILER TECHNICIAN OF THE WATCH - Senior BT in Fireroom, operates all automatic boiler controls, supervisors start and operation of all equipment in fireroom. (E-8) through (E-5).

32-UL - UPPER LEVEL MAN - Monitors boiler water level and insures proper level is maintained, starts and operates all fireroom equipment on upper level. (E-5) (E-4).

33-BN- BURNERMAN - Operates boiler front. (E-4) (E-3).

34-FIREROOM MSG - Monitors all remote gauges in fireroom, general assistant. (E-3) (E-2).

35-MMOW- MACHINIST MATE OF THE WATCH - Senior Machinist Mate supervisors all start and operation of all equipment in engine room. (E-8) (E-7) (E-6).

36-LL -LOWER LEVELMAN - Operates all equipment on Engine Room lower level. (E-5) (E-4).

37-THROTTLES - Operates Engine Throttles for ahead and astern operation of propeller. (E-4) (E-3).

38-ENGINE MSG - Engine Room Messenger, assists MMOW, monitors all engine room remote gauges. (E-3) (E-2).

39-SSTG SWBD Operator- Ships service turbine generator Switchboard Operator, Controls and monitors 60 cycle 400 volt electrical distribution throughout the ship. (E-3) through (E-7).

40- Gyro Watch_ Starts up the electic compass for true vice magnetic north, also controls all internal communication switchboards. (E-3) through (E-6).

41- After Steering - Starts the Steering motors and is backup steering control for the bridge. (E-3) through (E-6).

APPENDIX C

TRANSFER MATRIX OF SORTIE PERSONNEL

TRANSFER MATRIX FOR PERSONNEL

		1	2	3	4	5	6	7	8
1	OOD	0	0	5	5	1	1	0	1
2	JOOD	1	0	1	1	1	1	1	1
3	NAVPLOT1	.	.	0	0	1	1	5	1
4	NAVPLOT2	.	.	0	0	1	1	5	1
5	STB BRG	.	.	5	5	0	1	.	1
6	PORT BRG	.	.	5	5	1	0	.	1
7	BMOW	.	.	.	.	1	1	0	0
8	HELM	.	.	.	.	1	1	5	0
9	LEE HELM	.	.	.	.	1	1	5	0
10	BRIDGE STAT BOARD	.	.	.	.	1	1	5	0
11	CIC SUPERVISOR	.	.	1	1	1	1	.	5
12	CIC RADAR NAV PLOT	.	.	1	1	1	1	.	1
13	SPS 10 RADAR NAV	.	.	1	1	5	5	.	5
14	RADAR SURFACE SEARCH	.	.	10	10	5	5	.	10
15	NC2/DRT PLOT	.	.	.	.	5	5	.	5
16	1JV BRIDGE PHONE	.	.	.	.	10	10	.	1
17	JA/JL BRIDGE PHONE	.	.	.	.	10	10	.	1
18	1JV FORECASTLE	.	.	.	.	15	15	.	5
19	1 JV FANTAIL	.	.	.	.	.	.	.	.
20	LINE 1 NON TECH PERS	.	.	.	.	.	.	.	10
21	LINE 2 NON TECH PERS	.	.	.	.	.	.	.	15
22	LINE 3 TECH PERS	.	.	.	.	5	5	.	.
23	LINE 4 NON TECH PERS	.	.	.	.	.	.	.	10
24	LINE 5 NON TECH PERS	.	.	.	.	.	.	.	.
25	LINE 6 TECH PERS	.	.	.	.	.	.	.	5
26	1ST LT FORECASTLE	.	.	.	.	5	5	5	5
27	OIC/CPO AFT LINES FANTAIL	.	.	.	.	.	.	.	.
28	RADIO SUPERVISOR	.	.	.	.	.	.	.	.
29	RADIO ASSISTENT	.	.	.	.	.	.	.	.
30	EOOW	.	.	.	.	.	.	.	.
31	BTOW	.	.	.	.	.	.	.	.
32	UPPER LEVELMAN	.	.	.	.	.	.	.	.
33	BURNERMAN	.	.	.	.	.	.	.	.
34	FIREROOM MESSENGER	.	.	.	.	.	.	.	.
35	MMOW	.	.	.	.	.	.	.	.
36	LOWER LEVELMAN	.	.	.	.	.	.	.	.
37	THROTTLE	.	.	.	.	.	.	.	.
38	ENGINEROOM MESSENGER	.	.	.	.	.	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	.	.	.
40	GYRO WATCH	.	.	.	.	.	.	.	.
41	AFTER STEERING	.	.	.	.	.	.	.	10

TRANSFER MATRIX FOR PERSONNEL

		9	10	11	12	13	14	15	16
1	OOD	1	1	5	5	5	5	5	5
2	JOOD	1	1	10	5	5	5	5	5
3	NAVPLOT1	1	1	.	5	5	5	5	5
4	NAVPLOT2	1	10	.	5	5	5	5	5
5	STB BRG	1	1	.	.	10	.	.	1
6	PORT BRG	1	1	.	.	10	.	.	1
7	BMOW	0	0	.	.	.	.	.	1
8	HELM	0	0	.	.	.	.	.	1
9	LEE HELM	0	0	.	.	.	.	.	1
10	BRIDGE STAT BOARD	0	0	.	.	.	.	.	1
11	CIC SUPERVISOR	1	1	0	1	1	1	1	10
12	CIC RADAR NAV PLOT	1	1	5	1	1	1	1	1
13	SPS 10 RADAR NAV	2	1	.	0	0	1	1	1
14	RADAR SURFACE SEARCH	10	5	.	10	0	0	2	2
15	NC2/DRT PLOT	5	3	.	.	3	3	0	2
16	1JV BRIDGE PHONE	1	1	.	.	.	.	.	0
17	JA/JL BRIDGE PHONE	1	1	.	.	.	.	.	1
18	1JV FORECASTLE	5	5	.	.	.	.	.	5
19	1 JV FANTAIL	.	.	.	.	.	.	.	5
20	LINE 1 NON TECH PERS	5	5	.	.	.	.	.	5
21	LINE 2 NON TECH PERS	5	5	.	.	.	.	.	5
22	LINE 3 TECH PERS	.	5	.	5	5	5	5	5
23	LINE 4 NON TECH PERS	8	5	.	.	.	.	.	5
24	LINE 5 NON TECH PERS	.	5	.	.	.	.	.	5
25	LINE 6 TECH PERS	5	5	.	.	.	.	.	5
26	1ST LT FORECASTLE	5	5	.	.	.	.	.	5
27	OIC/CPO AFT LINES FANTAIL	.	5	.	.	.	.	.	5
28	RADIO SUPERVISOR	.	.	.	.	.	.	.	.
29	RADIO ASSISTENT	.	.	.	.	.	.	.	.
30	EOOW	.	.	.	.	.	.	.	.
31	BTOW	.	.	.	.	.	.	.	.
32	UPPER LEVELMAN	.	.	.	.	.	.	.	.
33	BURNERMAN	.	.	.	.	.	.	.	.
34	FIREROOM MESSENGER	.	.	.	.	.	.	.	.
35	MMOW	.	.	.	.	.	.	.	.
36	LOWER LEVELMAN	.	.	.	.	.	.	.	.
37	THROTTLE	.	.	.	.	.	.	.	.
38	ENGINEROOM MESSENGER	.	.	.	.	.	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	.	.	.
40	GYRO WATCH	.	.	.	.	.	.	.	.
41	AFTER STEERING	10	.	.	.	.	.	.	.

TRANSFER MATRIX FOR PERSONNEL

		17	18	19	20	21	22	23	24	25
1	OOD	5	5	5	.	.	.	.	.	.
2	JOOD	5	5	5	.	.	.	.	.	.
3	NAVPLOT1	5	5	5	10	10	10	10	10	10
4	NAVPLOT2	5	5	5	10	10	10	10	10	10
5	STB BRG	1	5	5	10	10	10	10	10	10
6	PORT BRG	1	5	5	10	10	10	10	10	10
7	BMOW	1	5	5	5	5	5	5	5	5
8	HELM	1	5	5	5	5	5	5	5	5
9	LEE HELM	1	5	5	5	5	5	5	5	5
10	BRIDGE STAT BOARD	1	5	5	5	5	5	5	5	5
11	CIC SUPERVISOR	1	5	5	10	10	10	10	10	10
12	CIC RADAR NAV PLOT	1	5	5	10	10	10	10	10	10
13	SPS 10 RADAR NAV	1	10	10	10	10	10	10	10	10
14	RADAR SURFACE SEARCH	2	5	5	10	10	10	10	10	10
15	NC2/DRT PLOT	2	8	8	10	10	10	10	10	10
16	1JV BRIDGE PHONE	1	5	5	8	8	8	8	8	8
17	JA/JL BRIDGE PHONE	0	8	8	8	8	8	8	8	8
18	1JV FORECASTLE	5	0	5	1	1	1	5	5	5
19	1 JV FANTAIL	5	5	0	5	5	5	1	1	1
20	LINE 1 NON TECH PERS	5	1	5	0	0	0	5	5	5
21	LINE 2 NON TECH PERS	5	1	5	0	0	0	5	5	5
22	LINE 3 TECH PERS	5	1	5	0	0	0	5	5	5
23	LINE 4 NON TECH PERS	5	5	1	5	5	5	0	0	0
24	LINE 5 NON TECH PERS	5	5	3	5	5	5	0	0	0
25	LINE 6 TECH PERS	5	5	1	5	5	5	0	0	0
26	1ST LT FORECASTLE	5	1	5	1	1	1	5	5	.
27	OIC/CPO AFT LINES	5	5	1	5	5	5	1	1	1
28	RADIO SUPERVISOR	.	.	.	.	.	.	.	.	.
29	RADIO ASSISTENT	.	.	.	.	.	.	.	.	.
30	EOOW	.	.	.	.	.	.	.	.	.
31	BTOW	.	.	.	.	.	.	.	.	.
32	UPPER LEVELMAN	.	.	.	.	.	.	.	.	.
33	BURNERMAN	.	.	.	.	.	.	.	.	.
34	FIREROOM MESSENGER	.	.	.	.	.	.	.	.	.
35	MMOW	.	.	.	.	.	.	.	.	.
36	LOWER LEVELMAN	.	.	.	.	.	.	.	.	.
37	THROTTLE	.	.	.	.	.	.	.	.	.
38	ENGINEROOM MESSENGER	.	.	.	.	.	.	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	.	.	.	.
40	GYRO WATCH	.	.	.	.	.	.	.	.	.
41	AFTER STEERING	.	.	.	.	.	.	.	.	.

TRANSFER MATRIX FOR PERSONNEL

		26	27	28	29	30	31	32	33
1	OOD	.	.	.	.	30	.	.	.
2	JOOD	5	5	.	5	60	.	.	.
3	NAVPLOT1	.	.	.	.	.	.	.	.
4	NAVPLOT2	.	.	.	10	.	.	.	.
5	STB BRG	.	.	.	.	.	.	.	.
6	PORT BRG	.	.	.	.	.	.	.	.
7	BMOW	5	5	.	.	.	.	.	.
8	HELM	.	.	.	.	.	.	.	.
9	LEE HELM	.	.	.	.	.	.	.	.
10	BRIDGE STAT BOARD	.	.	.	.	.	.	.	.
11	CIC SUPERVISOR	.	10	5	5	.	.	.	.
12	CIC RADAR NAV PLOT	.	.	.	5	.	.	.	.
13	SPS 10 RADAR NAV	.	.	.	10	.	.	.	.
14	RADAR SURFACE SEARCH	.	.	.	10	.	.	.	.
15	NC2/DRT PLOT	.	.	.	15	.	.	.	.
16	1JV BRIDGE PHONE	.	.	.	.	.	.	.	.
17	JA/JL BRIDGE PHONE	.	.	.	.	.	.	.	.
18	1JV FORECASTLE	5	5	.	.	.	.	.	.
19	1 JV FANTAIL	.	.	.	.	.	.	.	.
20	LINE 1 NON TECH PERS	.	.	.	.	.	.	.	.
21	LINE 2 NON TECH PERS	.	.	.	.	.	.	.	.
22	LINE 3 TECH PERS	5	10	10	5	.	.	.	.
23	LINE 4 NON TECH PERS	.	.	.	.	.	.	.	.
24	LINE 5 NON TECH PERS	.	.	.	.	.	.	.	.
25	LINE 6 TECH PERS	.	.	.	.	.	.	.	.
26	1ST LT FORECASTLE	0	5	.	.	.	.	.	.
27	OIC/CPO AFT LINES FANTAIL	5	0	.	.	.	.	.	.
28	RADIO SUPERVISOR	.	.	0	0	.	.	.	.
29	RADIO ASSISTENT	.	.	10	0	.	.	.	.
30	EOOW	.	.	.	.	0	15	15	15
31	BTOW	.	.	.	.	15	0	2	2
32	UPPER LEVELMAN	.	.	.	.	.	10	0	1
33	BURNERMAN	.	.	.	.	.	.	15	0
34	FIREROOM MESSENGER	.	.	.	.	.	.	.	2
35	MMOW	.	.	.	.	5	15	16	5
36	LOWER LEVELMAN	.	.	.	.	.	.	.	.
37	THROTTLE	.	.	.	.	.	.	.	.
38	ENGINEROOM MESSENGER	.	.	.	.	.	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	.	.	.
40	GYRO WATCH	.	.	.	.	.	.	.	.
41	AFTER STEERING	.	.	.	.	.	.	.	.

TRANSFER MATRIX FOR PERSONNEL

		34	35	36	37	38	39	40	41
1	OOD	.	.	.	.	.	.	.	.
2	JOOD	.	.	.	.	.	.	.	5
3	NAVPLOT1	.	.	.	.	.	.	.	10
4	NAVPLOT2	.	.	.	.	.	.	.	10
5	STB BRG	.	.	.	.	.	.	.	10
6	PORT BRG	.	.	.	.	.	.	.	10
7	BMOW	.	.	.	.	.	.	.	5
8	HELM	.	.	.	.	.	.	.	5
9	LEE HELM	.	.	.	.	.	.	.	10
10	BRIDGE STAT BOARD	.	.	.	.	.	.	.	10
11	CIC SUPERVISOR	.	.	.	.	.	.	.	15
12	CIC RADAR NAV PLOT	.	.	.	.	.	.	.	.
13	SPS 10 RADAR NAV	.	.	.	.	.	.	.	.
14	RADAR SURFACE SEARCH	.	.	.	.	.	.	.	.
15	NC2/DRT PLOT	.	.	.	.	.	.	.	.
16	1JV BRIDGE PHONE	.	.	.	.	.	.	.	10
17	JA/JL BRIDGE PHONE	.	.	.	.	.	.	.	15
18	1JV FORECASTLE	.	.	.	.	.	.	.	.
19	1 JV FANTAIL	.	.	.	.	.	.	.	.
20	LINE 1 NON TECH PERS	.	.	.	.	.	.	.	.
21	LINE 2 NON TECH PERS	.	.	.	.	.	.	.	.
22	LINE 3 TECH PERS	.	.	.	.	.	.	.	.
23	LINE 4 NON TECH PERS	.	.	.	.	.	.	.	.
24	LINE 5 NON TECH PERS	.	.	.	.	.	.	.	.
25	LINE 6 TECH PERS	.	.	.	.	.	.	.	3
26	1ST LT FORECASTLE	.	.	.	.	.	.	.	.
27	OIC/CPO AFT LINES FANTAIL	.	.	.	.	.	.	.	.
28	RADIO SUPERVISOR	.	.	.	.	.	.	.	.
29	RADIO ASSISTENT	.	.	.	.	.	.	.	.
30	EOOW	15	5	10	1	10	5	5	10
31	BTOW	3	10	15	15	15	15	30	30
32	UPPER LEVELMAN	1	30	30	5	15	60	90	90
33	BURNERMAN	1	.	.	5	15	.	.	.
34	FIREROOM MESSENGER	0	.	.	5	10	.	.	.
35	MMOW	15	0	2	0	2	5	10	.
36	LOWER LEVELMAN	.	10	0	1	1	15	.	.
37	THROTTLE	.	.	5	0	1	60	.	.
38	ENGINEROOM MESSENGER	.	.	20	5	0	.	.	.
39	SSTG SWBD OPERATOR	.	.	.	.	.	0	5	.
40	GYRO WATCH	.	.	.	.	.	5	0	.
41	AFTER STEERING	.	.	.	.	.	.	.	0

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